Forage Blower Development at International Harvester (A)

Feed is one of the most important factors in animal production. As a result of various experiments carried out, the basic feed requirements have been well established. With the advent of labor saving machines, experiments are being continued to determine the most economical way of planting, harvesting, storing and administering the feed to the livestock.

The traditional way of getting forage to the cow is to send the cow to the field. This is now thought to be a very inefficient way of feeding. Quoting an expert, S. A. Witzel, an agricultural engineer at the University of Wisconsin, "Looking ahead to 1980, I would say year round stored forage is definitely in the picture." He continued, "There will be some farms where pasturing will continue to be the only practical method of harvesting, but the better dairy farms will have no pasture in 1980."

Some years ago, the main feeds were hay and silage. Hay is made from mature grasses or legume plants cut and dried for use as fodder. The primary object in hay making is to reduce the water content of the green plants so that the hay can be safely stored. Without proper care, the hay will become moldy or undergo fermentation which can lead to heating and spontaneous combustion. The moisture content of stored hay is about 20%.

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Silage is a green forage crop such as grass, sorghum, corn and alfalfa. It is made into succulent feed for livestock by fermentation and has a percentage moisture of about 70%. During the past ten years there has been a considerable increase in the use of hay crops for silage because of the saving of green nutrients as compared to field drying. The silage is usually stored in a chamber called a silo.

Silos

In storing the silage, care is taken to keep out oxygen. After storing, a first fermentation takes place due to the presence of enzymes, microorganisms and oxygen entrapped in the silage. If normal respiration continues, molds and bacteria grow. If however, the silo is properly sealed against oxygen infiltration, the first stage comes to an end within a few hours after all of the oxygen originally entrapped has been used up. At this point the silage remains warm and filled with carbon dioxide. Other reactions then set in and produce acids and alcohol until the pH builds up to about 3.5 to 4.5. If the silage is properly packed and sealed from oxygen and rain, it can remain in this edible condition for many months.

There are two main types of silos, the horizontal silo and the vertical silo. In construction, the horizontal appears to be cheaper than the vertical silo. However, when made suitable for proper packing (to prevent spoilage due to weather and oxygen infiltration), the cost of the horizontal silo is almost the same as the vertical silo. The vertical silo has an advantage in that it takes up less space and, since less surface area is exposed to oxygen, there is little spoilage.

Modern Trends

Silage crops like corn and sorghum contain enough sugar to produce sufficient quantities of acids in the fermentation process to make good silage. With crops deficient in sugar like grains and legumes, particularly where they are of high moisture content, it has been usual to add artificial preservatives and conditioners. These include mixtures of hydrochloric and sulphuric acid, phosphoric acid and others. More recently it has been found that wilting the crop in the sun for two or three hours before ensiling acts as a good conditioner. Researchers calculate that the wilting reduces the water content so that the sugar content per pound of forage is increased. Hay thus prepared is referred to as wilted hay or more recently as haylage. The percentage of moisture content is between 40 and 60%.

Forage Blowers

Chopped forage is commonly elevated into the silo by an impeller blower which slings the material up a delivery pipe with an initial kinetic energy sufficient to carry it into the silo (Exhibit 1). The silage is dropped from a wagon or truck into a feed trough with slant or auger conveyor which delivers it into the impeller blower.

The efficiency of blowers is very low. Theoretically, only about 0.04 hp-hr is required to lift 1 ton 40 feet. In an actual impeller blower used in filling a 40 foot silo, the hay's kinetic energy amounted to 0.35 hp-hr per ton at 9,000 fpm peripheral velocity. However, tests at Purdue University indicated total power requirements of 1.1 to 2.0 hp-hr per ton for green alfalfa-timothy, 1/2 in. cut. Wilted hay may require about double this power. Much of the energy is lost due to friction of the material on the paddle blades and on the inside of the housing and delivery pipe. Enough energy has also to be provided to enable the material to turn around the delivery elbow at the top of the delivery pipe and go into the silo.

International Harvester

The International Harvester Corporation maintains a constant contact with agricultural research establishments and with farmers through their service representatives. They are, therefore, aware of any new discoveries or trends in farm practices. As this information becomes available, it is analyzed by the research departments to determine in what way it affects the company. Recommendations are then made at meetings of the Product Planning Committee, where an appropriate step is taken. Members of the Product Planning Committee include the Works Manager, the Chief Engineer and the Sales Representative.

As a result of reports from the sales, market survey, and research departments, the management teams involved with forage blowers in early 1958 noted the following trends:

1. There was a shift from the use of hay and silage as feed to the use of haylage. The friction coefficient of haylage is more than that of silage; therefore, when the existing blowers were used to elevate haylage into the silo, they were found to be very inefficient. The shift to higher silos put greater strain on the blowers, and in some cases, they were very uneconomical to maintain.

2. Competing firms were making larger blowers which were better suited for the popular new higher silos.

3. The current production blower of about 50 ton/hour capacity did not match the IH50 forage harvester of about 70 ton/hour capacity.

The Advanced Engineering group was then authorized to make preliminary studies and recommend unique features which the proposed blower should have.

They made a study of the operating characteristics of production machines on the market and came up with the following observations:

1. Right angle turns in the blower feed path for blowers such as that shown in Exhibit 2 forced the materials to stop twice before entering the blower. These stoppages make continuous and uniform flow of material impossible, thus reducing the capacity of the blower.

2. The necessity for an intermediate gear box for blowers such as that shown in Exhibit 3 increased the cost of the product and introduced some inefficiencies owing to an increase in the number of moving parts.

3. It has been found necessary to provide a long conveyor leading from the wagon to the blower in order to prevent interference between the wheels of the tractors driving the blower and the wagon. Where this was not provided, the farmer had to spend much time juggling the tractors in order to get the wagon as near as possible to the blower while at the same time trying to avoid the wheels of the tractor driving the blower (Exhibits 2 and 3 suggest this problem).

Additional information was obtained from research papers which might influence new blower design concepts. In particular, Raney and Liljedahl in a paper entitled "How the Impeller Blade Shape Affects Forage Blower Performance" noted,

"One of the major reasons for the low efficiency for forage blowers appears to be the result of friction between the forage material and the housing of the machine. Recent work with both forage harvesters and forage blowers indicate that friction accounts for as much as one-third to one-half of the total power requirements of a machine. A significant reduction in power requirements would seem possible if the blower could be designed to deliver the material directly up the pipe with little or no material ever reaching the housing."

Peripheral Feed Blower Concept

On the basis of such research reports engineers at International Harvester decided in early 1958 that the best place to introduce material into the blower was at the blower periphery. In that way it would flow straight through the blower without stoppage or turns. Since the materials are fed at a tangent to the periphery, the proposed blower was named "The Peripheral Feed Blower." Exhibit 4 shows a schematic diagram of the peripheral feed blower concept. The material is introduced into the blower at a tangent to the blower housing. The blade picks up the material, increases its kinetic energy, and discharges it through the outlet pipe. In this way there is a straight-through unrestricted flow of the material without the stops or sharp turns which are characteristic of the other blowers. Since all the materials are introduced at the periphery, there is little or no sliding of the materials relative to the blades. The only sliding friction is that between the material at the tip of the blade and the housing. The peripheral feed blower also simplifies power take off access and wagon access to the feed conveyor as shown in Exhibit 5.

The objectives of the peripheral feed blower development project were originally listed as follows by IH engineers:

1. Develop a new principle blower (peripheral feed) to replace the current production machines.

2. Increase the crop handling capacity to match the IH number 50 forage harvester (70 tons per hour).

3. Reduce the horsepower-per-ton ratio.

4. Make the blower suitable for handling chopped wilted hay (haylage).

Questions for Discussion

a) Outline a development program for the peripheral feed blower.

b) Discuss possible advantages or disadvantages of the new concept, beyond those already presented.

c) Attempt a calculation to estimate the efficiency increase of the peripheral feed blower over older models.

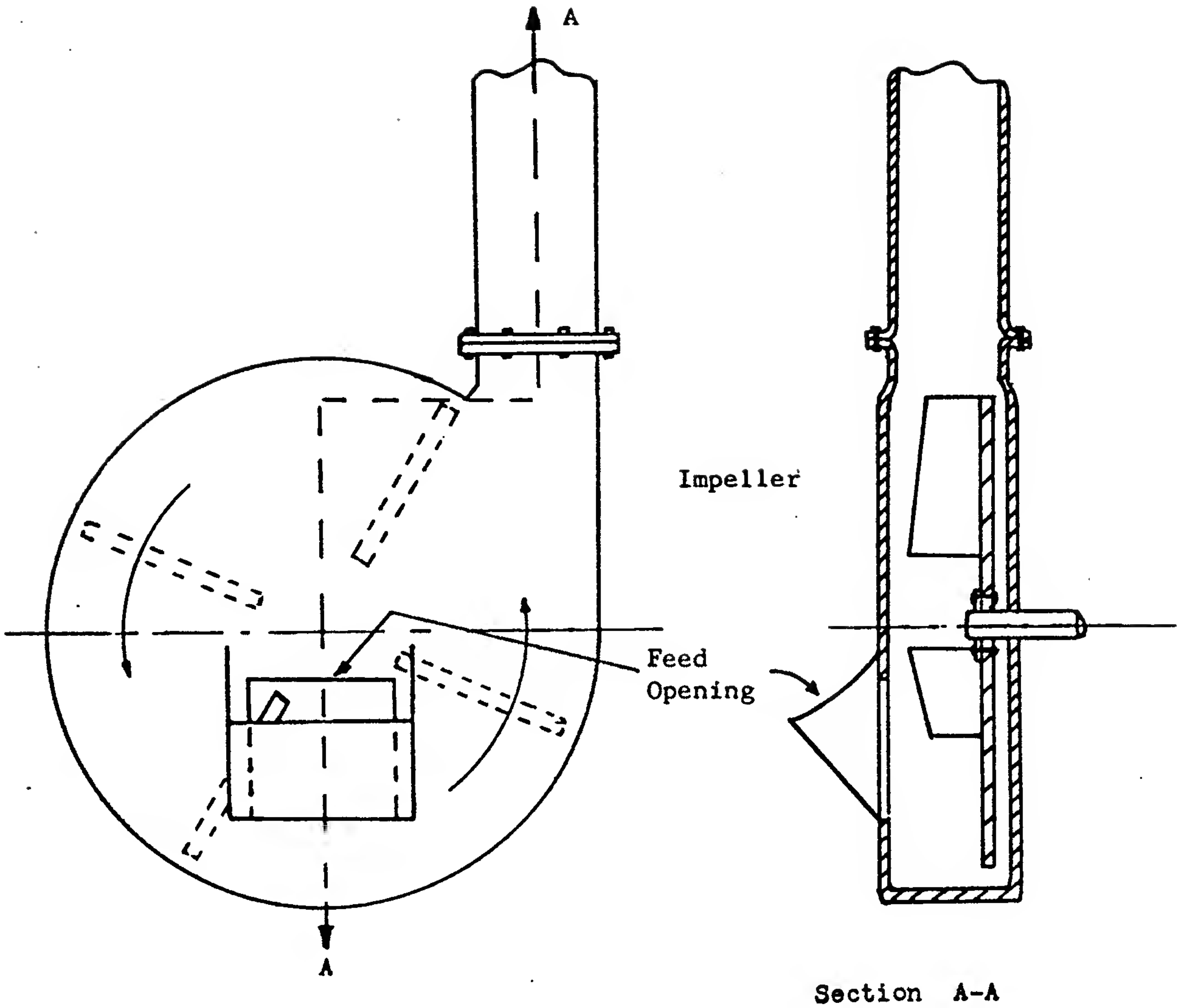

EXHIBIT 1 Typical Impeller Blower

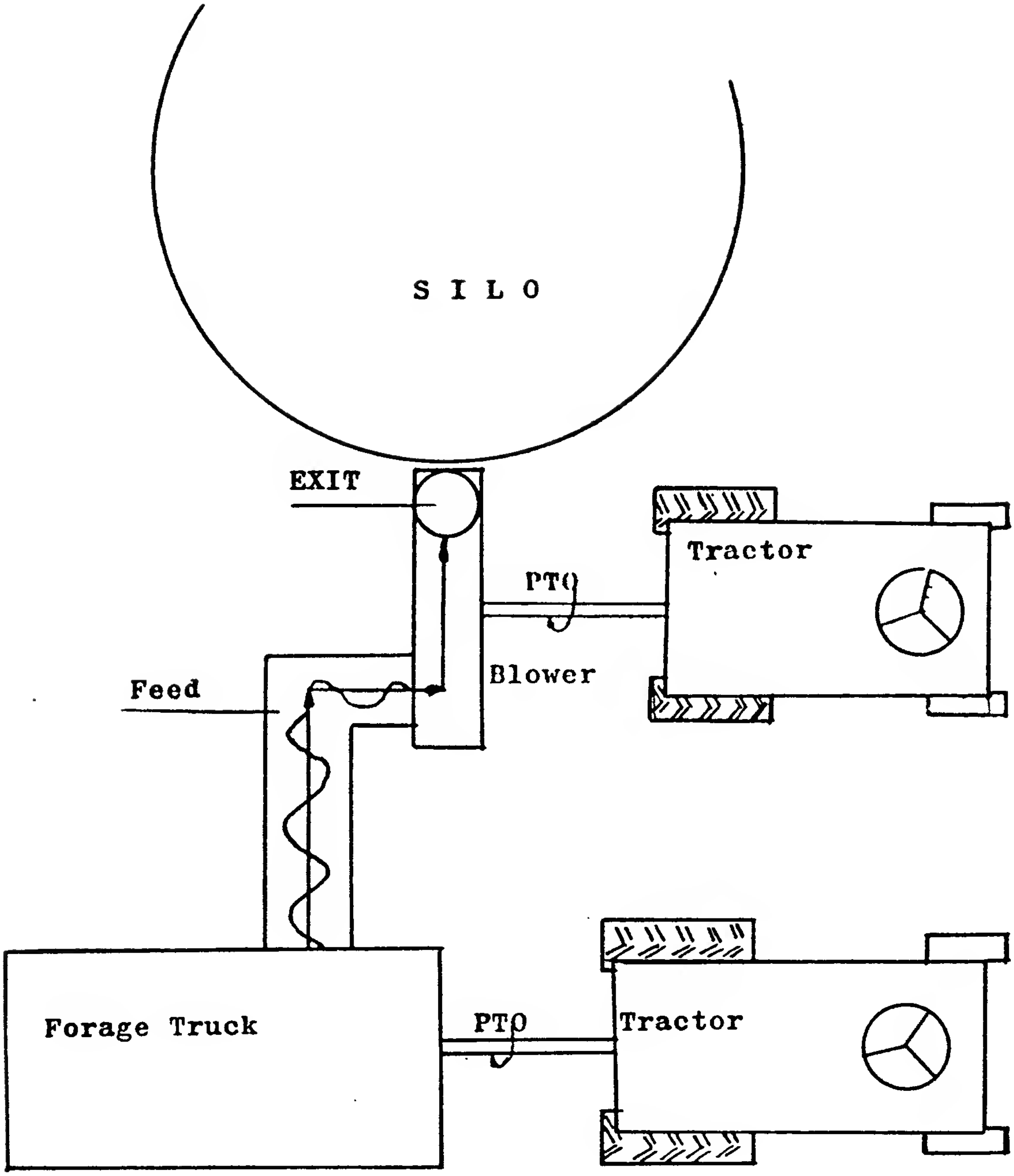

EXHIBIT 2

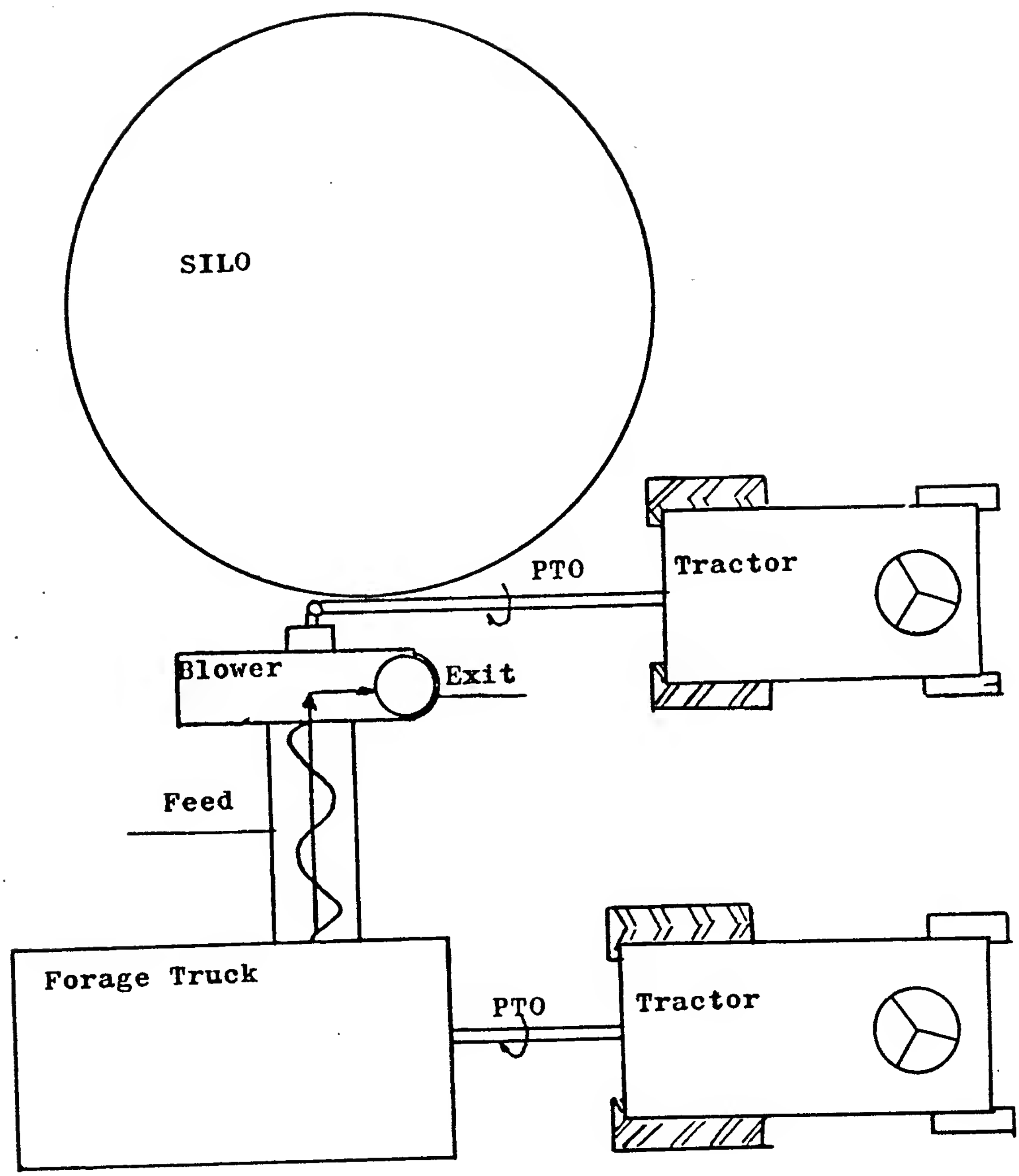

EXHIBIT 3

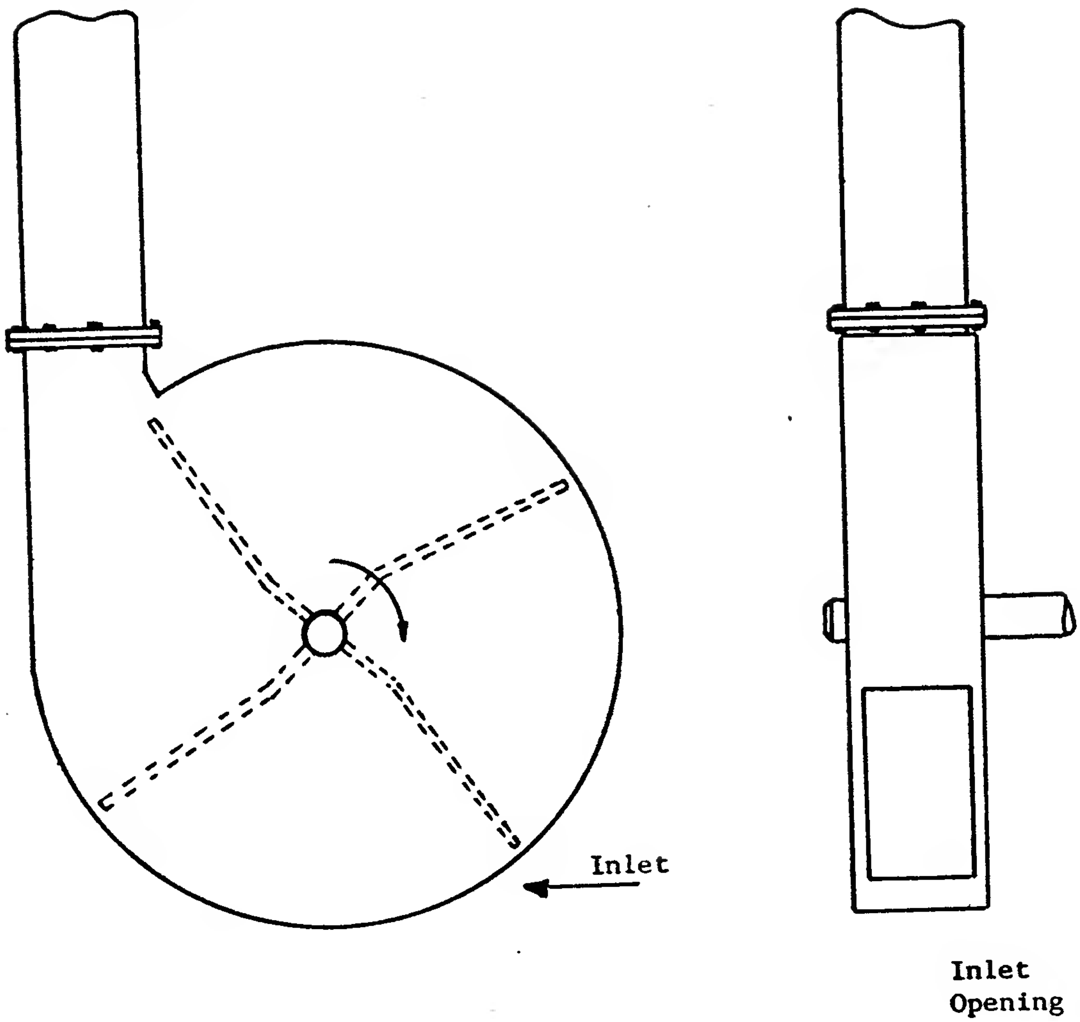

EXHIBIT 4 Peripheral Feed Blower

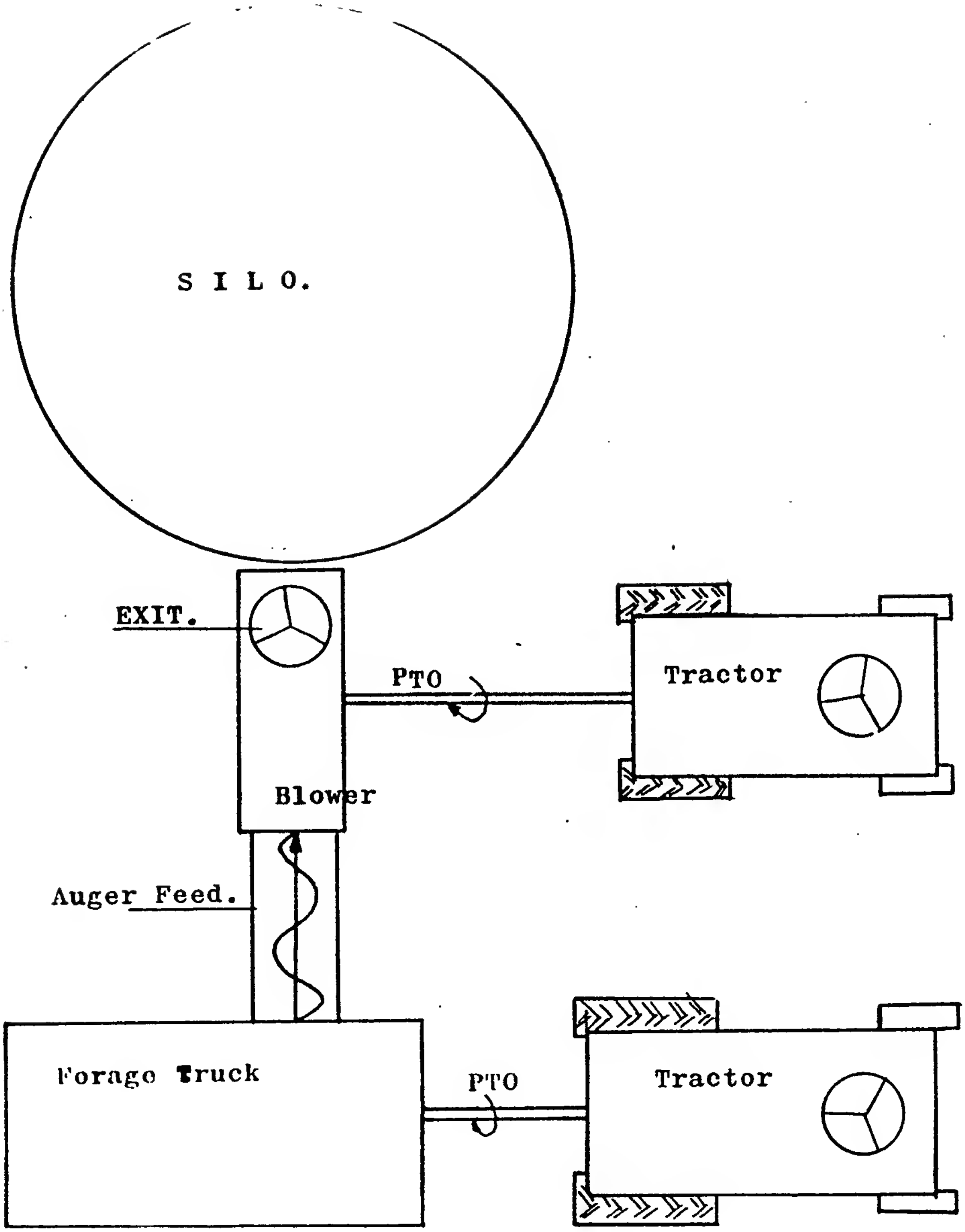
S I L O.
EXIT.
PTO
Tractor
Blower
Auger Feed.
Forage Truck
PTO
Tractor

Exhibit 5

Forage Blower Development at International Harvester (B)

Principles of Forage Blower Operation

Forage blowers have been subject to much research since their invention, and the results of these researches may be found in many scientific journals. The design engineers at International Harvester Company decided to use the information gathered from these publications, and to adapt it to suit actual operating conditions. As Mr. Scarnato, a product engineer in charge of blowers, says, "Since many papers have been presented on this subject, we felt it was reasonable to take these results and put them into actual practice. We, therefore, did not think it necessary to repeat the theoretical calculations ourselves."

Power Requirements in Blowers

Many of these investigations were aimed at understanding why the mechanical efficiency of blowers was so low. A few of these investigations and results are presented below in order to show what information was available at the time of the peripheral feed blower development planning. The following analysis was published by William Chancellor and Gordon Laduke, respectively, Assistant Agricultural Engineer and Senior Engineering Aid in the Department of Agricultural Engineering, University of California.

The analysis of power requirements can be made by considering the movement of particles within the blower. In an energy balance, the items which usually appear as output include:

1. Energy for air movement and air friction in the discharge pipe.

2. Kinetic energy of the thrown particles.

A more refined consideration also includes in the energy balance:

3. Energy absorbed by the particles in passing radially through the centrifugal field and lost partially through friction between the particles and the impeller blade and partially as the particles collide inelastically with the impeller housing.

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4. Energy lost due to friction force in the tangential direction as the particles collide with the impeller housing.

Each of these items is discussed in the report. Discussion of item 1 is postponed for the moment. For item 2, the velocity of particles leaving the impeller is taken to be equal to the tangential speed of the impeller tip.

The third item is

$$\frac{1}{2}\frac{W}{g}V_t^2 \qquad (1)$$

where V_t is the tangential velocity and W is the weight of material considered.

If the particle radial velocity just before impact with the impeller housing is known, the fourth item can be computed. Considering the collision of the particle with the housing as being inelastic and the change in V_t to be small, we have

$$\text{Momentum before impact} = M\,(\vec{V}_r + \vec{V}_t)$$

$$\text{Momentum after impact} = M\vec{V}_t$$

The change in momentum equals the impulse

$$MV_r = \int F_r dt$$

The friction energy loss during collision is

$$E = -\int F_t V_t dt = -\int f\, F_r V_t dt$$

where f is the average friction coefficient of the particles on the impeller or its housing.

Then; $$E = -\, f\, M\, V_r V_t = \frac{-W}{g} V_r\, f\, V_t \qquad (2)$$

It is convenient to let $V_r = \beta V_t$ where β is a constant depending on the friction coefficient, f.

Kamp, in an article which contains several mathematical analyses of impeller blower phenomena, gives $\beta = 1 - 0.7f$. The energy lost due to particle-housing friction is finally given by $E = -\,(W/g)f(1 - 0.7f)V_t^2$.

Relation Between Air and Solid Particles in Blower Pipe

A great portion of the power input to the blower is absorbed in producing air movement in the delivery pipe. It is difficult to measure the air movement under operating conditions because the solid particles interfere with the measuring instruments. Studies aimed at determining the influence of air on solid material are therefore usually done by combining pure air movement measurements (no solid particles) with an analytical description of air-solid interactions.

Once a particle has entered the delivery pipe, its movement soon becomes vertical. The particles and air may then be considered as moving under any of the following conditions.

Case I The particle moves upwards faster than the air stream.

Case II The air stream moves upwards faster then the particle but at a relative velocity less than the suspension velocity of the particle.

Case III The air stream moves upwards faster than the particle at a relative velocity greater than the suspension velocity of the particle.

The force on the particle is usually assumed to be proportional to the relative velocity. On the basis of these assumptions, Chancellor and Laduke developed some analytical equations which may be used to plot curves from which the interaction between the particle and the air may be predicted.

If the air velocity, V_a, suspension (or terminal) velocity, V_s, and initial relative velocity of the particle, V_{ro}, are known or assumed, values of the relative veloicty may be computed versus particle duration in the pipe. These results are shown in Figure 1 of Exhibit 1 for $V_a = 100$ fps, $V_s = 17$ fps, and $V_{ro} = 50$ fps. Such a plot permits computation and construction of a plot of particle height, H_t, relative to its original point in the pipe as a function of time (Figure 2). From these two plots the velocity at exit and the time taken to traverse the pipe may be predicted for any set of initial conditions.

As the particle moves through the pipe its velocity is affected by two factors:

(i) The product of the acceleration of gravity and the time during which it acts and

(ii) The force exerted between the air column and the particle.

From Figures 1 and 2 the overall change in particle velocity and the time, t, may be determined, and by multiplying t by the gravitational constant, g, the velocity change due to gravity may also be determined.

The difference between the velocity change due to gravity and the overall velocity change is due to the force between the particle and air colume. This difference (ΔV_f) is related to the force in question, F, by $m\Delta V_f = \int F\,dt$ giving

$$\frac{dm}{dt}(\Delta V_f) = F$$

where $\frac{dm}{dt}$ = rate of mass flow and F = the force of the air column on the particle and (temporarily neglecting pipe friction) the opposing force required to maintain a given velocity of the air column. The force, F, divided by the pipe area is, then, the pressure difference between the top and bottom of the pipe.

__Example__

If the following conditions exist:

V_a = 100 ft/sec

V_{ro} = 50 ft/sec (particle velocity 150 ft/sec)

V_s = 17 ft/sec (estimated from data on straw and grain by Persson)

Rate of feeding = 10 lb/sec = 600 lb/min

Pipe diameter = 9 in.

Pipe height = 41 ft.

Case I as plotted in Figure 2 gives:

t = 0.33 sec (from 0 to 41 ft)

and the particle velocity relative to the air stream at the exit is (by Figure 1)

V_r = 9.2 ft/sec

Particle velocity = 100 ft/sec + 9.2 ft/sec = 109.2 ft/sec and

Total velocity change = 150 ft/sec - 109.2 ft/sec = 40.8 ft/sec.

The portion of this caused by gravity = 0.33 sec x 32.2 ft/sec^2 = 10.6 ft/sec.

Thus, the part due to friction is

V_f = 40.8 ft/sec - 10.6 ft/sec = 30.2 ft/sec

and the friction force is

$$F = \frac{10 \text{ lb/sec of material}}{32.2 \text{ ft/sec}^2} \times 30.2 \text{ ft/sec} = 9.38 \text{ lb}$$

$$\text{Pressure difference} = \frac{F}{A} = \frac{9.38 \text{ lb}}{63.7 \text{ in}^2} = .148 \text{ psi} = 4.1 \text{ in. } H_2O$$

Notice that this is a pressure increase, whereas the pipe friction with a flow alone would have caused a pressure decrease of 2.35 in. H_2O.

Experiments on Particle-Air Interactions

In an actual test performed by Chancellor and Laduke, an Allis-Chalmers forage blower was fitted with an adjustable restriction at the inlet. To the outlet was attached a 14 ft. vertical section of 9 1/4 in. pipe with a Pitot tube fixed on the center of the pipe at the top. On top of this was attached a 4 ft. section of pipe and an adjustable restriction.

Inlet openings of 1/2, 2 1/2, 5 and 7 1/2 inches by 16 inches were used to simulate the inlet blockages caused by various rates of feeding. The blower was operated at 600, 750 and 900 rpm.

At each operating condition, static and dynamic pressures were recorded as the outlet restriction was varied from fully open to fully closed. Static pressures were corrected for pipe friction to give the value at the pipe inlet. Figure 10 in Exhibit 1 shows the results of some of these tests.

These tests of blower air movement characteristics and the theoretical analysis presented previously for interaction between particles and air in the blower exit pipe were then combined by Chancellor and Laduke to estimate forage blower performance. Their results are given in Figures 6, 7, 8, 9 of Exhibit 1.

Figure 6 shows that, for the conditions indicated, the pressure of the blower outlet will decrease as the rotational speed (initial particle velocity) of the blower is increased. Examination of similar figures prepared for various rates of feeding indicate that at 1200 lb per minute, the pressure decreases will be more pronounced as speed increases, but that at 400 lb per minute, pressure will remain essentially constant as speed changes. Figure 7 shows the dominant influence of air velocity on the particle exit velocity from a pipe. This indicates that the primary function of air movement in the pipe is to reduce the effect of air resistance on the solid material.

Figure 8 illustrates that if the blower is operated at the conditions indicated with a large unblocked inlet area, little would be gained in air stream velocity if the pipe size were reduced from 9 inches to 6 inches. However, with a 2 1/2 x 16 inch unblocked opening, air velocity would be increased by using a 6 inch pipe. In all cases, increasing pipe size from 9 to 12 inches would result in a lower air velocity. Figure 9 indicates the effect of pipe length.

Figure 11 shows that these analyses are sufficiently complete to explain measured physical conditions since the predicted and measured values are remarkably similar in both magnitude and characteristics.

Questions for Discussion

1) Derive the formulas for plotting Cases I and II of Fig. 1 in Exhibit 1.

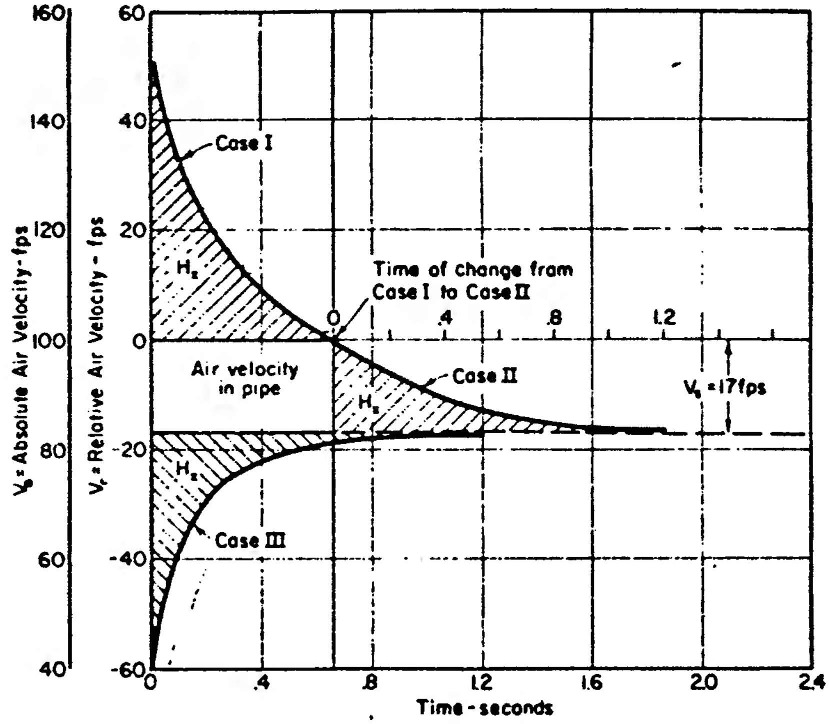
2) Some blowers may be operated so that some particles are thrown directly up the delivery pipe without touching the impeller housing. Develop a method for calculating frictional losses for collision of such particles with the delivery pipe wall for such a blower.

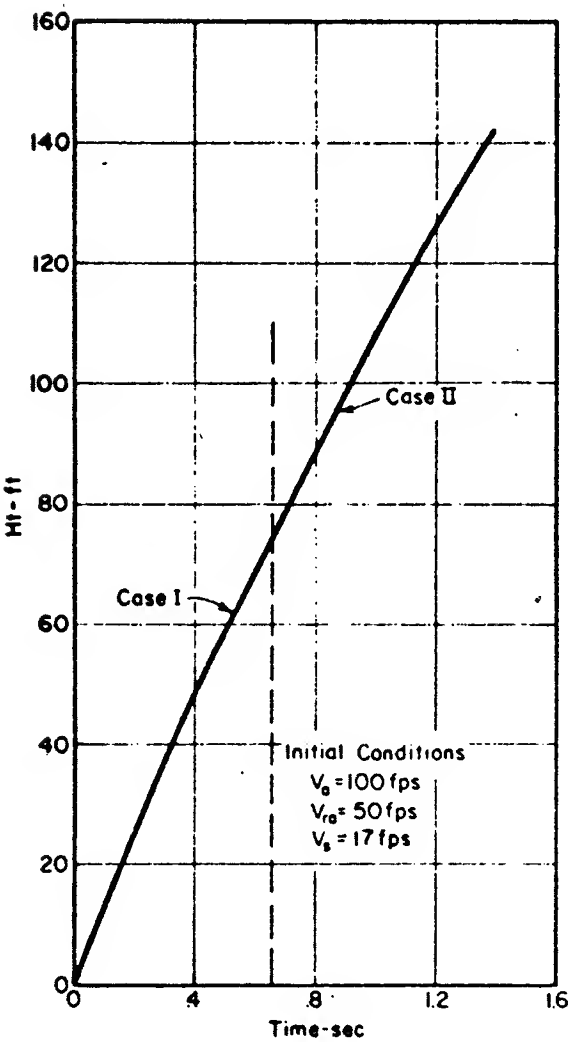
3) What conclusions concerning the design of the peripheral feed blower may be drawn from the results of these investigations?

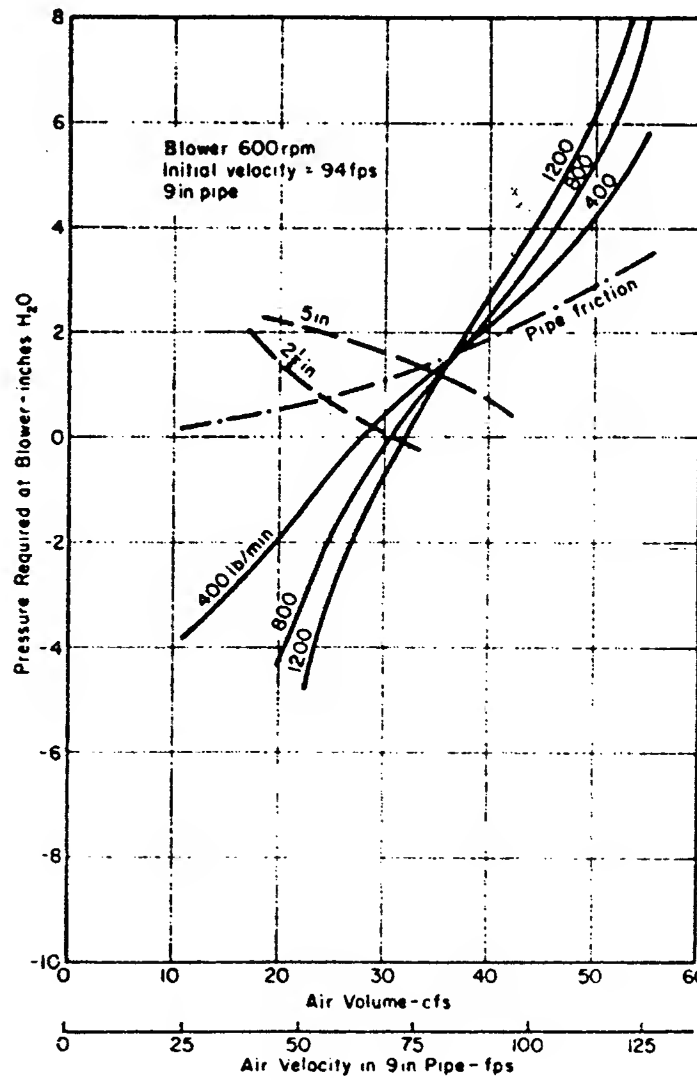
Fig. 1 (right) Examples of particle velocity changes with time.

Fig. 2 (below, left) Example of particle height increase with time.

Fig. 3 (below, right) Pressure–velocity relationships (blower at 600 rpm).







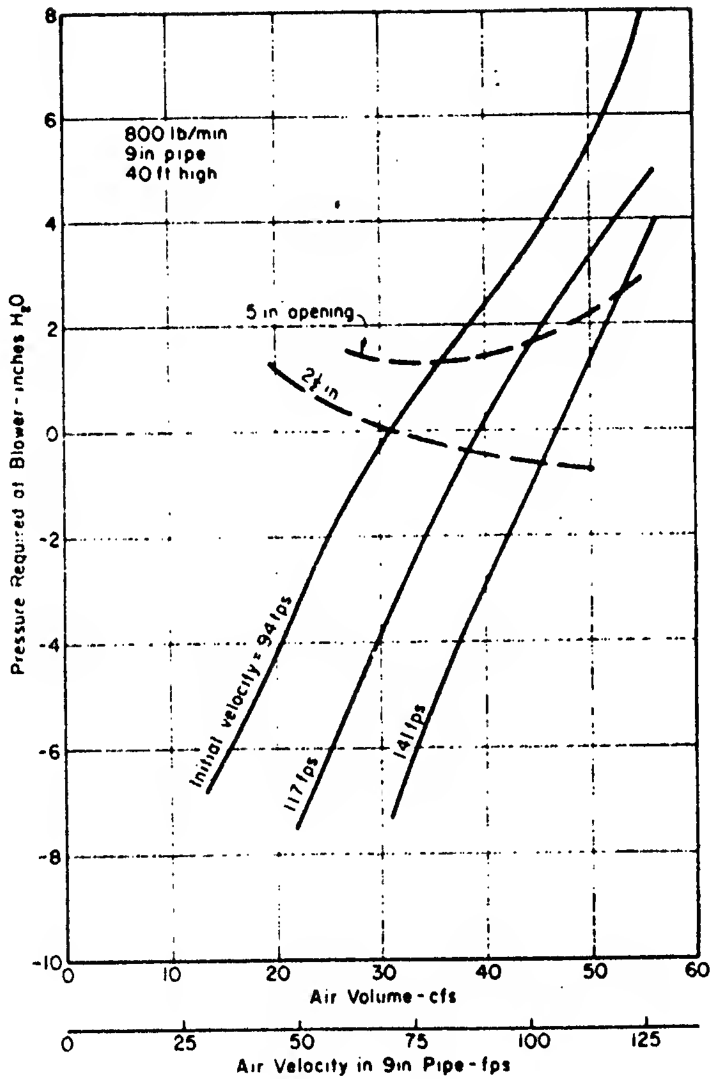


Fig. 6 Effects of various initial particle velocities on required air characteristics.

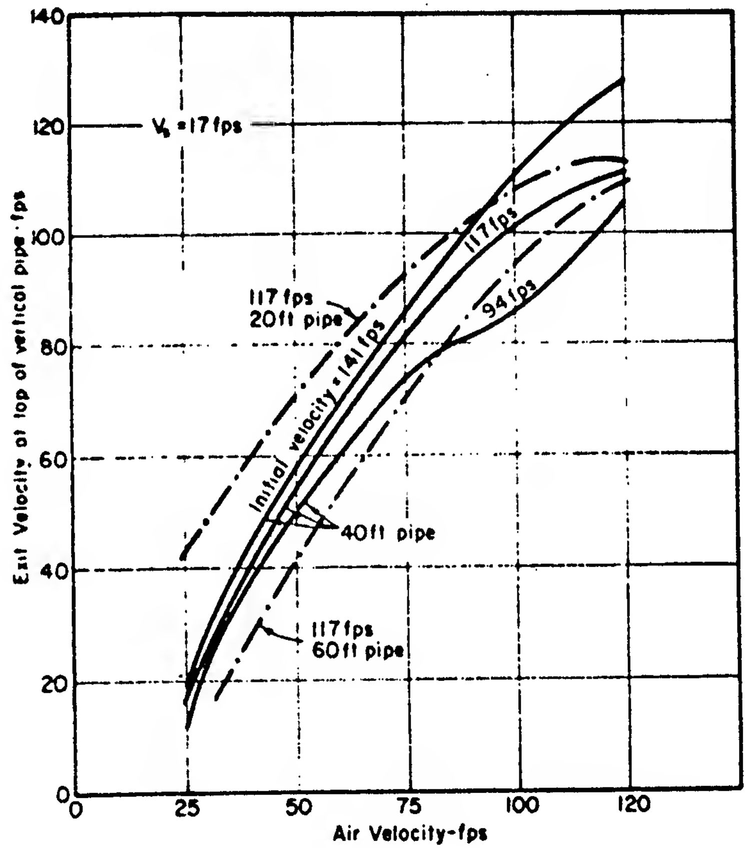


Fig. 7 Particle exit velocities in relation to air velocity.

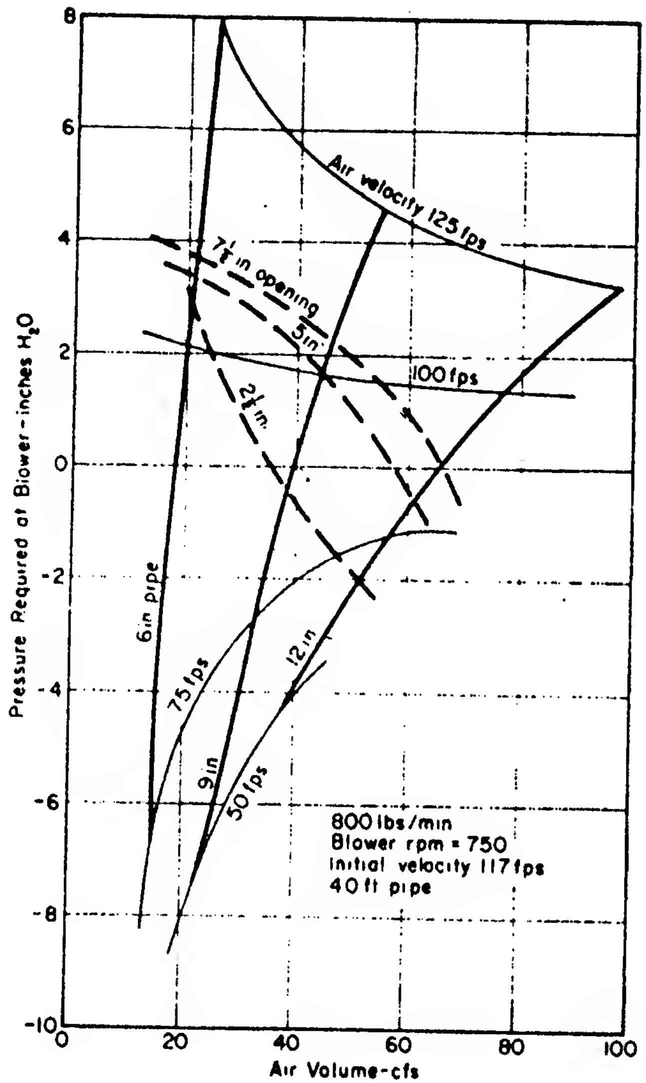


Fig. 8 Effects of fitting pipes of various diameters to a given blower.

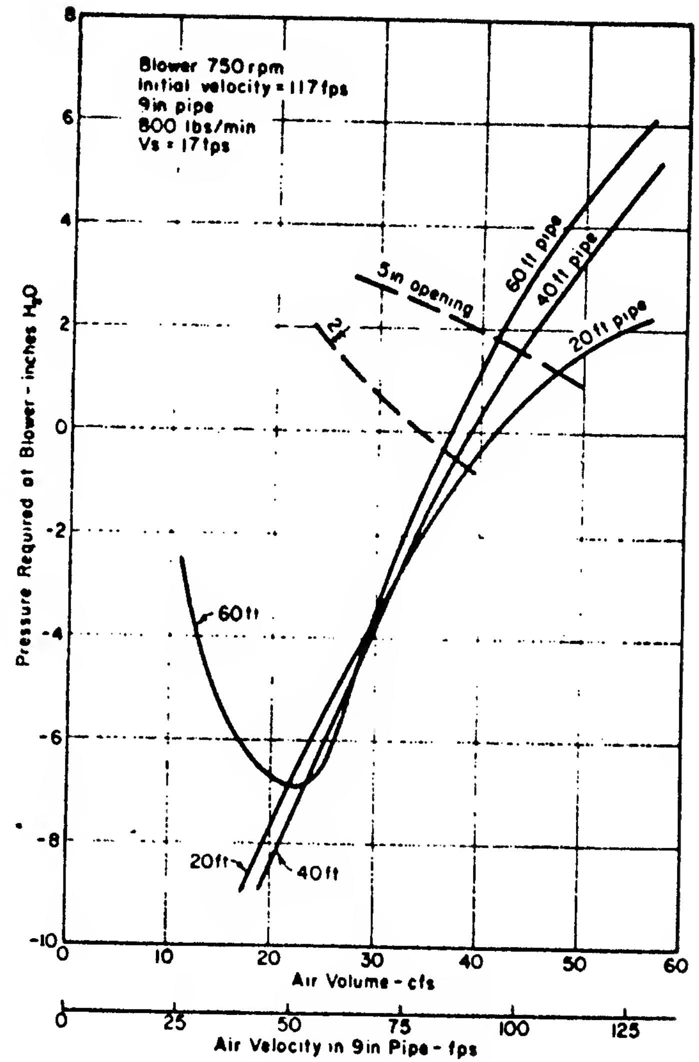


Fig. 9 Effects of fitting pipes of various lengths to a given blower.

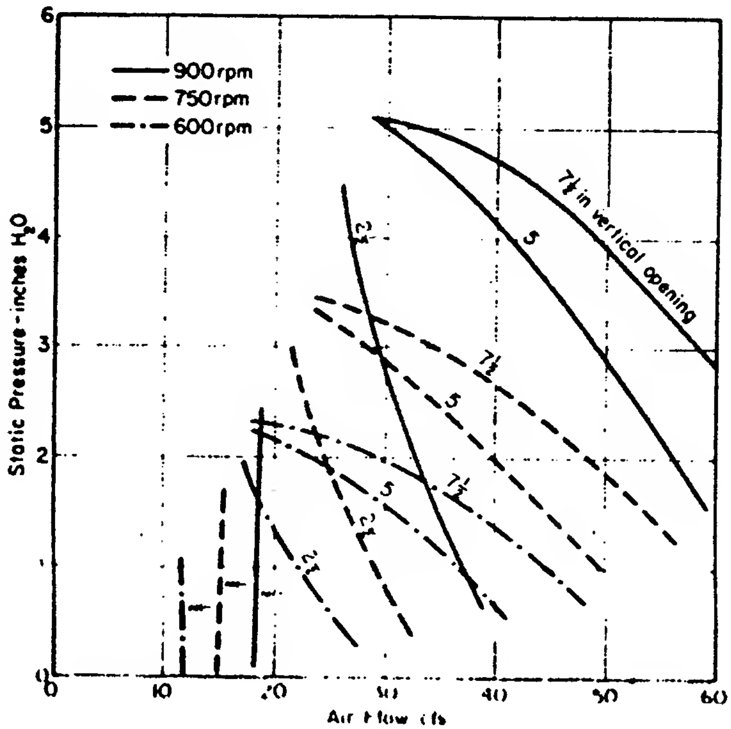


Fig. 10 Blower air movement characteristics.

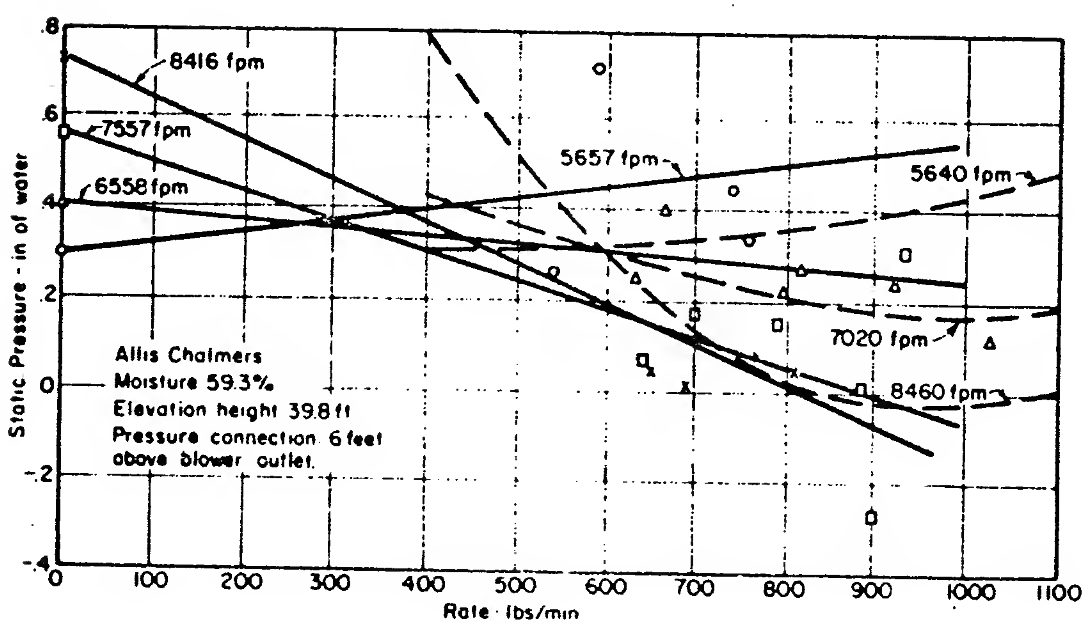


Fig. 11 Comparison of experimental and computed values of static pressure in the pipe. Solid lines and experimental points from Smith (7); dashed lines computed.

Forage Blower Development at International Harvester (C)

Development of the Peripheral Feed Blower

As described in Part A, International Harvester decided to develop the peripheral blower concept into a working model. Exhibit C-1 shows the basic concept. From previous experiments it was known that the air movements in the blower greatly affect its material handling characteristics. The first phase of development of the peripheral feed blower involved various experiments, by the Advanced Implement Department, to determine the effects on air and material handling of feed opening design, feed mechanism, rotor speed and rotor blade angle. An experimental peripheral blower was assembled using parts of earlier models for these tests.

1960 Model

The first difficulty encountered with the 1960 peripheral feed blower was that air blast at the feed opening tended to prevent dry material such as hay or corn leaves from entering the blower. The air blast caused a "dead spot" for air movement on the conveyor at the point where the air hits the conveyor. This point is located slightly forward of a tangent to the rotor at the top of the feed opening (Exhibit C-2). To correct this fault the scroll was vented just above the feed opening (Exhibit C-3) to discharge some of the air to the atmosphere in an effort to prevent the air discharge (positive pressure) at the feed opening. This did not eliminate the undesirable condition.

A forage blower generally obtains its highest feed rates with corn ensilage or a similar material having heavy, high density particles. This material is thrown into the silo rather than being blown. If there are any long dry leaves, high air velocity is required to blow the leaves into the silo. Because of the partial air discharge at the feed opening, the experimental 1960 peripheral blower had a very low exit air velocity and therefore had difficulty in blowing relatively dry materials. To improve the air handling capacity and reduce the material feeding problem the scroll just above the feed opening was vented and the air redirected into the blower (Exhibit C-4). No improvement was observed in the air movement, nor was there a reduction in the air curtain at the feed inlet.

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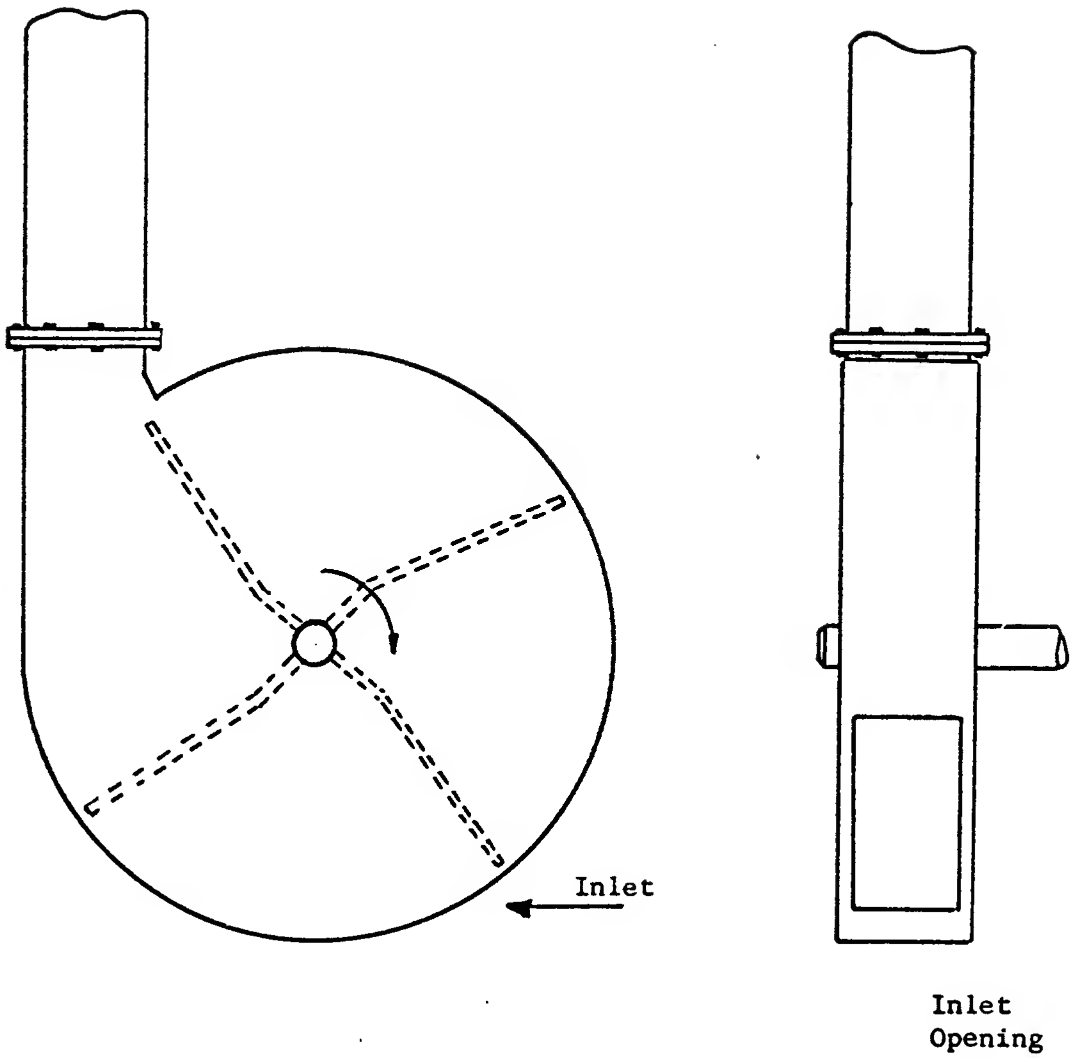
Another illustration of the importance of air in the pipe was noted. When the feed opening was completely covered with material, the air intake and air discharge were stopped. At this time, if there was any material in the pipe, it slowed to a stop and plugged the pipe. To prevent this from happening, vent openings were cut into the side of the blower housing near the center of the impeller. Various venting patterns and rotor blade configurations were tested with results as shown in Exhibit C-5. Air discharge occurred at the feed opening, indicating continued material feeding problems, with all configurations tested.

Experiences with low air handling and material feeding troubles in the 1960 peripheral feed blower dictated changes for the 1961 model. The problem of low air handling efficiency was eliminated by providing a feed opening considerably wider than the rotor and extending all the way to the rotor core. The 1960 blower had delivered 1565 cfm of air at 740 rpm with 40 feet of 9 inch discharge pipe. The 1961 experimental model with a wide feed opening delivered 1945 cfm at 540 rpm, 2110 cfm at 600 rpm, and 2570 cfm at 720 rpm with 56 feet of 9 inch discharge pipe.

A report describing experiments performed on the 1961 model blower was submitted by the Advanced Implement Department to management in December, 1961. (Exhibit C-6 contains an excerpt from this report). This report and the 1961 experimental blower were given to the Product Engineering Department for final development of a production prototype. From early 1962 until early 1964 the blower was bounced back and forth between the Advanced Implement Department and the Production Department. Finally a version of the blower designated the Model 62 (Exhibit C-7) was in final tests which, if successful, would have resulted in its being slated for production. However, a responsible engineer in the Product Engineering Department, Tom Scarnato, remained unsatisfied. He performed several experiments of his own and decided that the feed opening could not be located at a tangent to the periphery. The air blast at the feed opening and the plugging which were observed at high feeding rates were decisive.

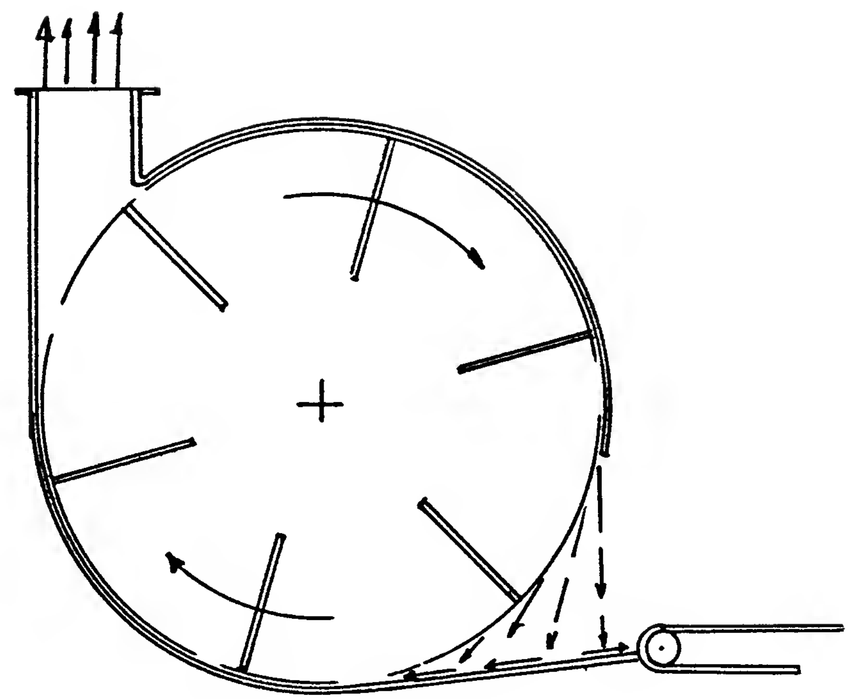
Questions for Discussion

1) How should IH proceed with the development from this point?
2) How can the results of the experiments described be explained?



Peripheral Feed Blower

Exhibit C-2



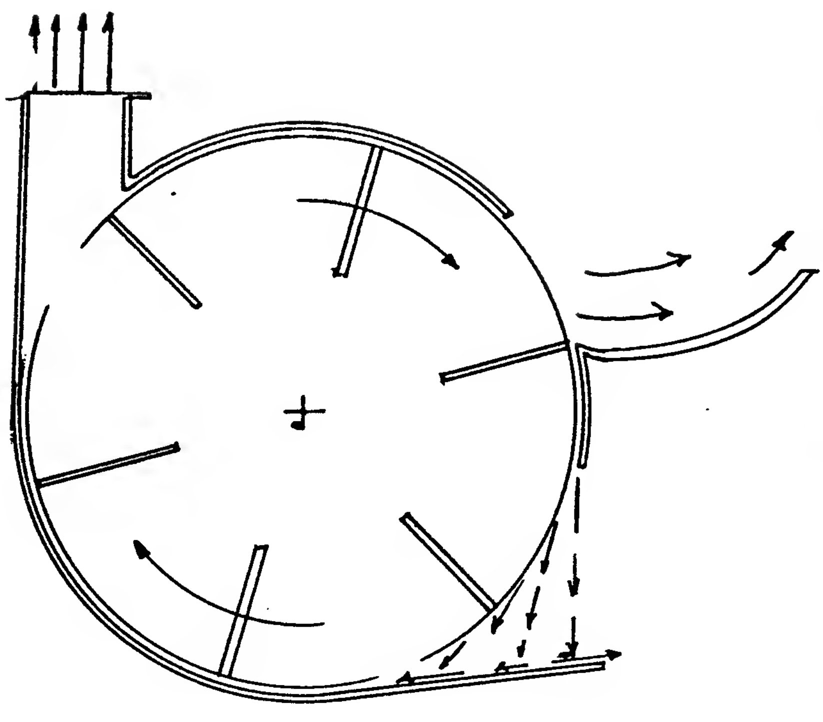


Exhibit C-3

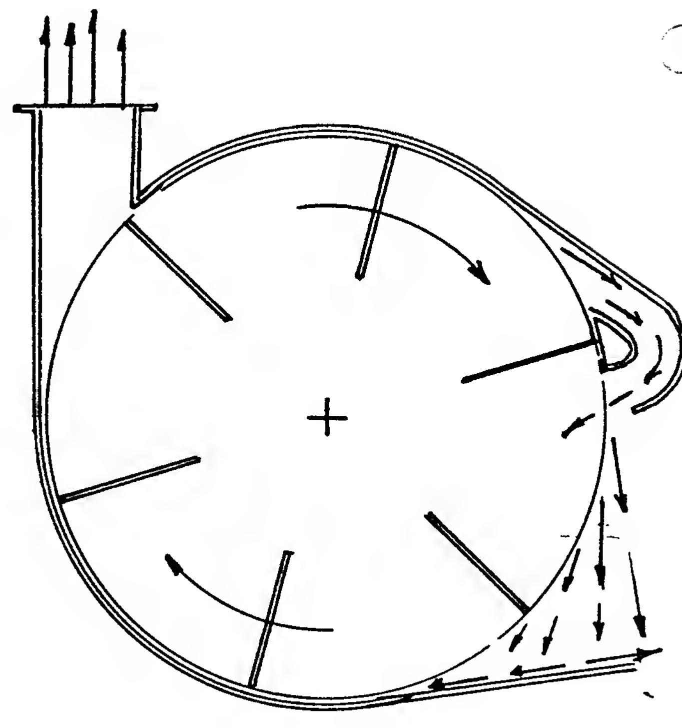


Exhibit C-4

Air handling characteristics of the 1960 peripheral blower with the pipe removed

Curve	Holes open	Blade type	No. blades
1	none	1	6
2	A	1	6
3	A,B	1	6
4	C	1	6
5	A,B,C	1	6

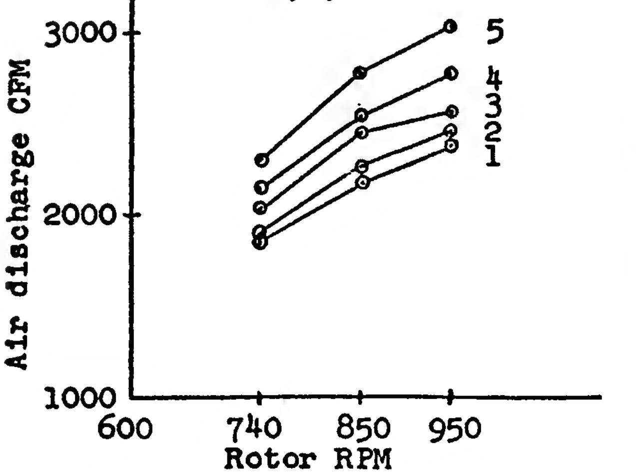


Chart 1 Effect of side holes on the air discharge rate of blade type 1

Curve	Holes open	Blade type	No. blades
1	none	4	12
2	none	4	6
3	none	3	6
4	none	2	6
5	none	1	6

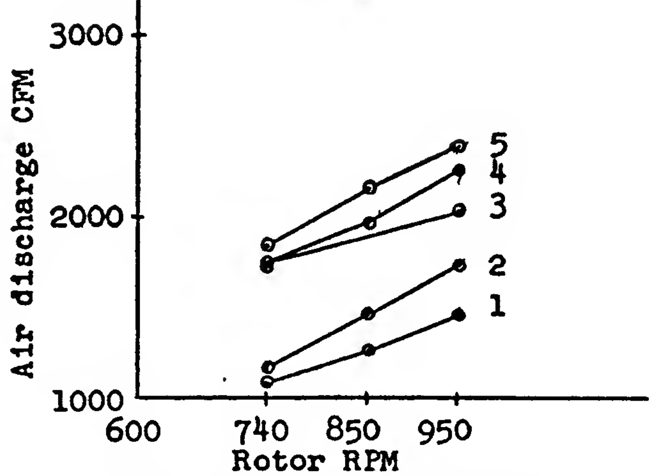


Chart 2 Effect of blade type on the air discharge rate

Curve	Holes open	Blade type	No. blades
1	none	4	12
2	B	4	12
3	A	4	12
4	A,B	4	12
5	A,B,C	4	12
6	A,B,C	4	6

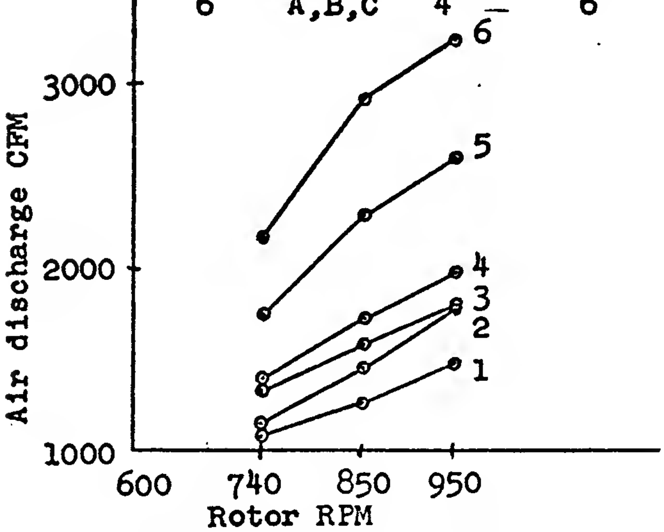


Chart 3 Effect of side holes on the air discharge rate of blade type 4.

Curve	Holes open	Blade type	No. blades
1	A or B	4	12
2	A,B	4	12
3	A,B,C	4	12
4	A,B,C	4	6

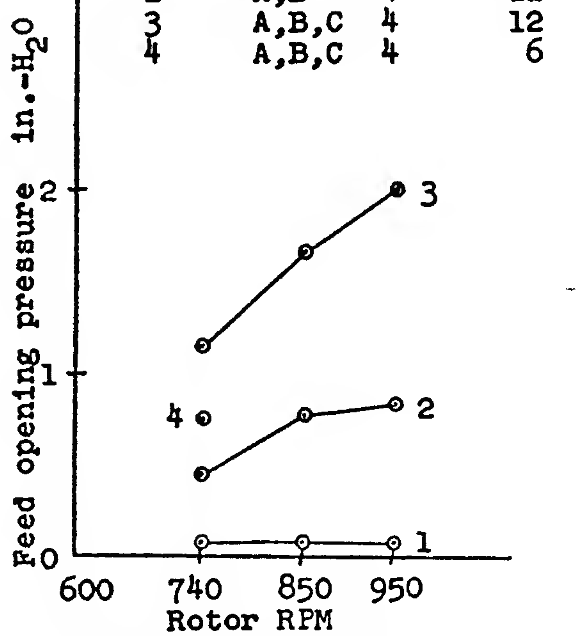
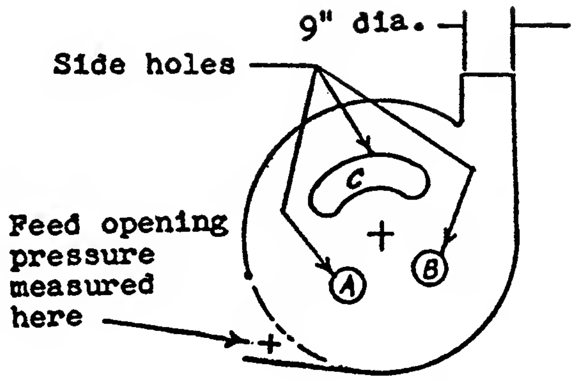
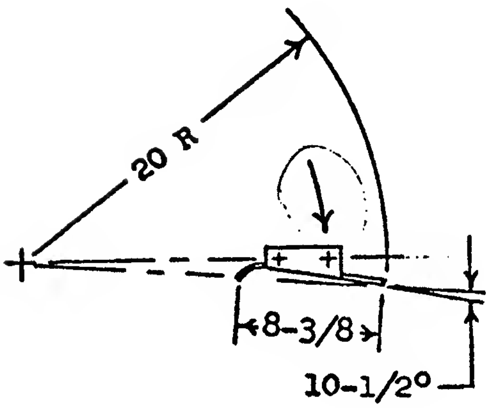


Chart 4 Effect of side holes on feed opening pressure of blade type 4.

RESULTS & DISCUSSION (Continued)

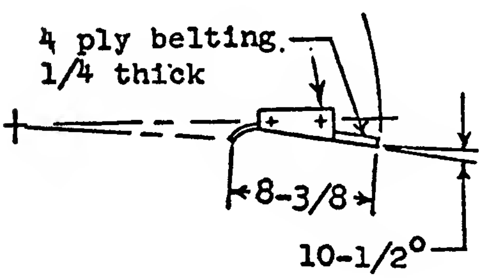
Rotor blades and side holes used in
the 1960 blower air handling tests





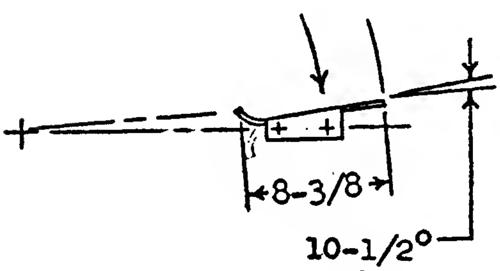
Blade 1

10-1/2° forward curvature



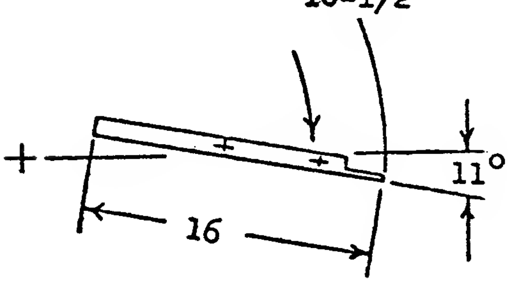
Blade 2

Same as blade 1 except the blade
tip is flexible



Blade 3

10-1/2° backward curvature



Blade 4
11° forward curvature extending
to within 5" of the rotor center

Material Handling Characteristics

High feed rates (table 4) have been obtained with the peripheral blower. The high feed rates with light, low density materials such as long wilted hay is partially due to the wide feed opening which allows a straight through, unrestricted flow of material into the blower.

Table 4

Peripheral Feed Blower (1961 Model)

Material Blown	Corn Ensilage	Green Flail Chopped Alfalfa	Short Chopped Green Alfalfa	Dry Chopped Hay	Long Chopped Wilted Hay
Silo height (ft.)	60	60	60	60	60
Moisture %	50	60	50	15	40
Average Horsepower	53.6	54.5	42.7	41.5	--
HP - Hrs./Ton	.654	1.06	1.1	2.30	--
Ave. Feed Rate Tons/Hour	82.2	51.8	41	17.8	15.4

Some of the values in table 4 may be compared to values in table 5 for the I.H. No. 45 blower. However, these tests were not run side by side with the peripheral blower tests. The values for the I.H. No. 45 blower have been taken from Test Engineering reports reference no. (1), (2), (3) and (4).

Table 5

Experimental No. 45 Blower

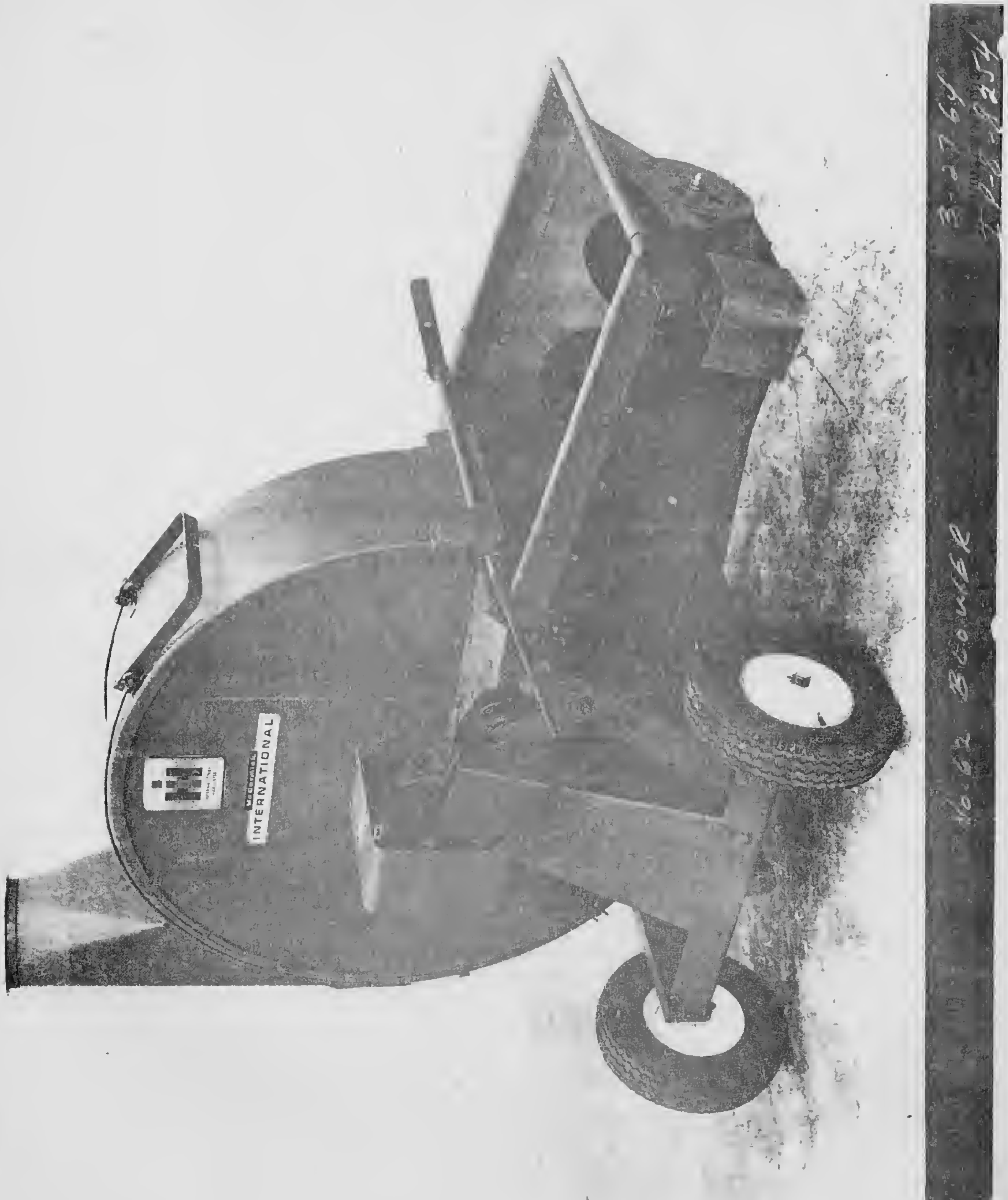
Based on Test Engineering reports of the No. 45 blower, docket number 61604 dated December 13, 1960, June 19, 1961, August 10, 1961 and September 6, 1961, the following data was reported:

Material Blown	Corn Ensilage		Short Chopped Wilted Hay	Long Chopped Wilted Hay
Reference	(1)	(2)	(4)	(3)
Silo Height *	50	30	40	35
Moisture %	65	53	25 - 40	55
Average Horsepower	41.1	54.4	33.0	17.2
HP - Hrs./Ton	.670	.958	1.17	2.25
Ave. Feed Rate Tons/Hr.	61.8	56.8	28.0	7.66

*The silo height is the height of the actual silo used for the tests. These are not necessarily the maximum heights for material elevations.

Exhibit C-7

ECL 106C



ECL 106D

ENGINEERING CASE LIBRARY

Forage Blower Development at International Harvester (D)

The Model 56 Forage Blower

Tom Scarnato, the engineer responsible for forage blower development in the Product Engineering Department at IH, decided in May, 1964, that the peripheral feed blower was not working properly. He also knew that IH's forage blower sales would be stimulated by introduction of an improved model and that this blower development was important to the company.

From reports and experiments on the Model 62 blower, Tom recognized that the two big problems were the air curtain at the feed entrance and the tendency of the blower to plug when materials were fed unevenly.

Earlier tests had shown that widening the feed opening helped reduce the air curtain at the feed inlet. In fact, the material on the feed conveyor had forked rather than entering the impeller at its periphery and actually had entered the impeller diagonally from the side. The Product Engineering and Test and Development groups had then designed and built a conveyor with two augers feeding to the two sides of the periphery. Material had piled up between these augers, but otherwise this design seemed to be an improvement.

Working for and with Tom on the project were product design engineers, test engineers and draftsmen. Regarding design improvements and modifications, Tom says, "We like people who can mix a practical approach along with their education. Our business is to make a profit and we often have to come up with a new product very quickly to do it. When a problem comes up we have a bull session on it and everyone contributes."

Prepared by Ibanga Ekong and Rollin C. Dix of Illinois Institute of Technology for the Engineering Case Library of Stanford University.

On September 4, 1964, Tom and his group held a bull session on the experiments with the forage blower. Tom felt that if they could keep the forage moving at the 425 ft/min velocity at which it is delivered to the blower by the wagon cross conveyor, the would satisfy one of the original reasons for the peripheral blower -- avoiding right angle turns. Experiments had shown that the material "wanted" to flow diagonally into the blower, not at the periphery but three to four inches from the periphery. Accordingly, the idea of a diagonal feed conveyor grew. Tom says, "You almost know when you have something. You have a good feeling inside. We had a solution. We didn't know how good, but we sent our idea to our patent attorneys that very day!" ExhibitD-1is extracted from the patent issued later. This patent gives IH the choice to exclude others from manufacturing and selling blowers with diagonally placed feed conveyors.

The Bear Implement Company* is today one of IH's chief competitors in the forage blower field. In 1964 their 52 inch blower's feed conveyor was of the usual type, perpendicular to the impeller plane. Tom Scarnato redesigned this conveyor to feed at 45 degrees to the impeller plane and had a Bear blower modified to his design in the IH experimental shop. This unit was given the code name "Red Bear". When tested, it required 21% less power for the same capacity than the unmodified blower. Tom now knew he had something.

To make optimum use of the new principle, the diameter of the new design IH blower was increased to 56 inches to provide greater capacity and throwing power. Continued testing and developing resulted in the Model 56 Blower described in ExhibitD-2. The first units, selling for about $680.00, were shipped from IH's East Moline plant in June, 1966. Within two years IH participation in the blower market had increased significantly.

<u>Questions for Discussion</u>

1) What percentage of kinetic energy is saved by the diagonal feed?

2) What other improvements in forage blower design can you suggest?

3) What accounts for the increased efficiency of the diagonal feed blower?

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* Fictitious name

United States Patent Office 3,302,978
Patented Feb. 7, 1967

3,302,978

DIAGONAL FEED MATERIAL CONVEYOR AND BLOWER MECHANISM

Thomas J. Scarnato, Park Ridge, Robert Sorensen and James J. Dryan, Chicago, and Craig M. Lawler, Downers Grove, Ill., assignors to International Harvester Company, Chicago, Ill., a corporation of Delaware

Filed May 28, 1965, Ser. No. 459,852
14 Claims. (Cl. 302—37)

This invention relates to material conveyors and more specifically to the type incorporating a blower for mechanically and pneumatically conveying material entrained in the air stream.

The blower is exemplified in the mechanism for blowing forage crops although it will be understood that in its broad aspects it may have application to other uses.

In forage blowers particularly, the blower mechanism comprises a fan which is encased within a housing, the fan normally rotating about a substantially horizontal axis and having a series of radially extending paddles which are adapted to engage the material which is being fed into the housing either through the side of the housing or through the periphery of the housing and to discharge the material through a tangential upwardly directed opening. In forage blowers the upwardly directed opening is formed as a duct which connects to suitable piping adapted to be positioned along side a silo to discharge forage crops into the upper end of the silo as is well known to those skilled in the art. Conventional forage blowers incorporate a feed trough which is directed to discharge a stream of material through a side of an upright housing parallel to the axis of rotation of the blower fan whereby the material is caused to enter into the fan at right angles to the direction of rotation of the fan so that the material must change its direction of movement at right angles. This is accomplished by the paddles or the fan blades striking the material and carrying it circumferentially of the housing to the discharge opening. We have found that this transition in the direction of movement of the material in being so abrupt greatly increases the power requirements of the mechanism. Furthermore for a given size of rotor in the type of forage blowers heretofore used in feeding the material at right angles to the direction of movement to the fan taxes the capability of the mechanism to an extent such that it operates far below its maximum capacity.

In the right angle feed to the blower the inertia of the material as it is exiting into the blower rotor must be overcome. Then the material must be given an impetus in a direction normal to its initial velocity. Increasing the size of the rotor and of the conveyor delivering to the rotor greatly compounds the problems. Feeding of the material through the periphery also poses problems in that the intake of the material is partially opposed by air blasts which are directed by the blades of the rotor toward the inlet opening.

A further problem inherent in material blowing mechanisms of current design is in the complications arising from the construction of the conveying mechanism which delivers the material into the blower rotor. This conveying mechanism must be arranged to move the material initially transversely and then direct such material in a direction perpendicular to the plane of rotation of the blower rotor. This arrangement of conveying of the material is occasioned by current farming practices which utilize a forage box or wagon which discharges from the side of the box. Forage blowers normally are mounted behind a tractor and an operator with a loaded wagon pulls up alongside the tractor which drives the blower and jockeys the wagon so as to get its discharge mechanism aligned with the conveyor of the blower. This is not only time consuming and tedious but frequently is almost impossible to accomplish depending on the terrain locations, etc. of the setup. Furthermore, the transition mechanism for moving the crop material from the forage box to the blower conveyor usually requires several active or powered mechanism which not only complicates the structures but adds to its cost. Frequently this mechanism must be supplemented by hand raking.

A general object of the invention is to provide a novel material blowing mechanism which incorporates a rotor blower and where the conveying air to the blower is so arranged so as to optimize delivery of material thereto.

A further object of the invention is to provide a material blower which incorporates a blower rotor rotatable about a substantially horizontal axis and a conveyor arranged to deliver to the blower from a side thereof with a stream of material entering the rotor diagonally thereto in the direction of rotation of the rotor.

A further object of the invention is to provide a novel material blower mechanism wherein the delivery of the material into the rotor and the structure of the inlet opening into the rotor housing is so designed as to fluff and aerate the material in order to obtain an efficient entrainment of the material into the airstream to effect efficient propulsion thereof.

More specifically the invention contemplates provision of a blower rotor rotatable about a substantially horizontal axis within an upright housing having an upwardly directed peripheral discharge opening and an inlet opening through the side of the housing and wherein the conveyor is disposed substantially at 45° to the plane of the rotor so that the acceleration of the material by the conveyor augments the action of the rotor in discharging the material from the blower housing.

More specifically the invention contemplates arranging the conveyor with the blower in such a way that the momentum of the material as it is discharging into the blower is utilized to propel it through the blower.

These and other objects and advantages inherent and encompassed by the invention become more readily apparent from the specification and the drawings, wherein:

FIGURE 1 is a rear elevational view of the novel blower partly in section taken substantially on the line 1—1 of FIGURE 2, a fragmentary rear elevation of a wagon discharging into the blower being shown.

FIGURE 2 is a plan view of the novel material blower fragmentarily illustrating the invention in connection with a tractor and in association with a forage discharge tractor-trailer wagon combination.

FIGURE 3 is a side elevation view of the right side of the novel blower.

FIGURE 4 is a horizontal cross sectional view taken substantially on line 4—4, FIGURE 3 on a larger scale.

FIGURE 5 is a side elevation view of the left side of the novel blower.

FIGURE 6 is a cross sectional view taken substantially on line 6—6 of FIGURE 5.

FIGURE 7 is a rear end view of the blower with certain shielding removed, and

FIGURE 8 is an enlarged side elevational view of the clutch operating linkage.

Description of the invention

In the drawings there is shown a forage or material blower generally designated 2 which comprises a generally cylindrical blower housing indicated at 3 which has a pair of vertical axially spaced substantially radial sidewalls 5 and 6 and a peripheral wall 7 which is provided with an outlet opening 9 (FIG. 1) extending substantially tangentially with respect to the peripheral wall 7 and communicating with an upwardly directed duct or piping 10.

The casing or housing 3 is connected to a framework generally designated 12 which includes front and rear frame sidings 14 and 15 embracing the casing 3 therebetween and integrated suitably either by bolting or welding with the respective sidewalls 5 and 6.

The inverted U-shaped frame 15 comprises a top frame member 17 (FIG. 1) and a pair of laterally spaced leg members 18 and 19 which at their lower ends are connected by a substantially horizontal axle beam 20 the opposite ends of which are provided with suitable spindles mounting support wheels 21, 22.

The frame structure 14 is integrally connected to the forwardly converging side beam members 24, 25 of the A-shaped draft frame 26, said beam members 24, 25 being suitably connected at their rear ends as by welding or bolting to the frame structure 14 and at their forward ends being provided or connected to a suitable draft clevis 27 which may be connected in any suitable way as by a pin to the draft frame or drawbar 29 which is mounted on an associated motivating and propelling unit such as a tractor diagrammatically fragmentarily illustrated at 30 in FIGURE 2.

The frame structure 14 also supports a bearing assembly 31 (FIG. 4) adjacent to the wall 3 on the beam member 32. The bearing structure 31 supports a shaft 34 which is suitably connected through a universally jointed power shaft 35 to the power-take-off shaft 36 which is normally positioned at the rear end of the tractor 30. It will be understood that the input of power to the blower conveyor unit may be from any source.

The shaft 34 is connected to the hub 38 of an impeller or rotor generally designated 40 said impeller comprising a plurality of radial arms 41 (FIG. 4) each of which carries a paddle 42 at its outer extremity. Each paddle extends widthwise axially of the rotor and has its outer edge 43 spaced radially inwardly slightly from the internal periphery 44 of the peripheral casing wall 7. The rotor 40 is rotated in the direction shown by the arrow in FIGURE 1 and rotates about a substantially horizontal axis as defined by the shaft 34 which is supported from the wall 6 and associated framework 15 by a bearing 45 (FIG. 4). The shaft 34 projects beyond the rear side of the casing 3 and is connected by means of universally jointed shafting 46 to a shaft 48 which extends horizontally diagonally with respect to the axis of the shaft 34. The shaft 48 is journalled at its rear end in a bearing 49 which is mounted on an upright wall 50 at the rear end of a conveyor trough structure generally designated 51. The shaft 48 is provided with a pulley 52 which drives a belt 53 (FIGS. 4 and 7), said belt being wrapped about a pulley 54 which is connected to a support shaft 55 of an open ended conveyor auger 56. The belt passes under a tightener pulley 57 which has an adjustable connection as at 58 about its axis of rotation with a mounting bracket 59 said mounting bracket 59 being pivoted on a suitable bolt or pin assembly 60 about a substantially horizontal axis to the inner wall 50 of the trough. The bracket 59 is pivotally connected at 61 to the lower end of a first toggle link 62 which at its upper end is pivoted as at 63 to a second toggle link 64, the latter toggle link 64 being connected to a shaft 65 which is journalled to the inner wall 50. Shaft 50 is fixedly connected to or on integral part of an operating arm or handle 66 which swings under, around and over the top of the conveyor trough as best seen in FIG. 7 and is provided with an overhanging portion 68 which terminates in a handle 69 for grasping by the operator who is stationed at the opposite side of the machine. It will be realized that swinging the handle upwardly as shown in dotted lines in FIGURE 7, that is in a counterclockwise direction, releases the idler pulley 57 by positioning the linkage and the idler pulley as shown in dotted lines in FIGURE 7 and swinging the control arm 66 reestablishes the drive in the previous position by swinging the parts into the position shown in solid lines in FIGURE 7 whereby tightening the belt about the pulleys 52, 54 to establish drive to the auger 56.

It will be observed that the auger shaft 55 is supported at its free end in a bearing structure 70 which is carried by a wall support 71 connected across angular wall portions 72, 73 of an outer rear wall structure 74.

The outer rear wall structure 74 also forms the rear end of a hopper 75 which has a lateral edge portion 76 which in the position shown in FIGURE 2 extends in a fore and aft direction with respect to the operating tractor 30. The hopper 75 has a bottom downwardly inclined wall 77 which is perimetrically encompassed by the wall portion 73, 76 and a front wall portion 78 which is suitably connected with the rear wall 6 of the blower by a flange structure 79 which extends substantially normal to the wall 6 about the periphery of an inlet opening 80 in the rear side of the housing. The diagonal wall 77 merges with a concave bottom wall portion 85 (FIG. 6) which in turn merges with an upright rear wall 86 said walls 86 and 77 defining a downwardly converging V and the wall 85 being at the apex of the V and conforming substantially to the underside of the auger 56 which extends at substantially a 45° angle to the plane designated A—A (FIG. 4) of the blower rotor 40.

As before mentioned, the auger 56 is carried by the shaft 55 which in addition to the bearing mounting at 70 also has a bearing mounting at 88 from the inner wall 50 whereby the auger 56 which is an open ended auger and is cantilever supported is held securely from sagging against the bottom wall 85. It will be realized that the flights 89 of the auger 56 are arranged to provide for a downward sweep of material as it is being unloaded over lip 76 from the side conveyor 90 of the wagon 91 pulled up alongside the hopper 75. The conveyor 90 is part of a wagon 91 which is adapted to be pulled alongside the blower conveyor. The wagon 91 may have a hitch 92 which may be suitably connected to the draft drawbar 93 of an associated tractor 94.

It will be readily realized that the instant conveyor lends itself very readily to an efficient discharge operation from a wagon inasmuch as the auger 56 is oriented in the direction of flow of the material from the transverse conveyor 90 and the material is conveyed substantially in the direction of its flow into the blower inlet opening 80 which it will be appreciated is located in the lower righthand quadrant of the blower housing as seen in FIGURE 6. The acceleration of material as it is discharging into the blower is not diminished therefore it augments the action of the blower in discharging the material through the discharge chute 10.

Another important feature of the invention is in providing a novel baffle structure generally designated 95 (FIG. 6) which comprises a top wall 96 having an extension behind the wall 86 with a depending portion 97 for shielding the drives 48 and 46 and the clutch control mechanism 65. A portion 98 of the wall 96 extends over the auger 56 and at its edge adjacent to the inlet edge 76 of the trough is provided with a downwardly and outwardly sloping deflector wall portion 99 which overhangs the opening 80. This shroud structure channels the air which exits from the opening 80 in a swirling pattern as indicated by the arrows in FIGURE 6 training some of the material which works its way over the top of the auger and with a blast of air causes this material to reenter into the housing and to be carried into and to fluff material being carried by the paddles and to entrain that material also into an airstream which further augments the flow of the material through the discharge duct 10. It will be noted that the inlet opening has a curved bottom edge 82 slightly above the peripheral wall 7 as best seen in FIGURE 6, the edge conforming substantially to the contour of the bottom wall 85 of the trough and that the trough walls 86, 77 converge toward the housing and that the upper edge 100 (FIG. 6) of opening 80 is substantially horizontal. Thus the inlet opening 80 is wider at the top than at the bottom to allow the air to enter through the upper portion of opening 80 readily into the eye of the rotor over the material being discharged into the rotor by the auger whereby this air is then impelled by the blades radially outwardly into the material therebeneath and thereby moving it into the airstream. The shroud or helical swirl creating means has a portion 120 along the downstream edge 121 of opening 80 and the upstream edge 122 of opening 80 is open. The helical swirl of air and material is about an axis coaxial with the axis of the inlet opening 80. It will be realized that a novel blower is obtained having a high material handling efficiency. Also by providing a trough with a receiving area which extends longitudinally of the tractor as well as the forage wagon with which it is to be associated, the handling of the material and the flow of the material is optimized. The auger rotates in the direction of the arrow (FIG. 6) so that the material is swept downwardly into the inlet 80 and discharges in the direction of movement of the impeller into the blower housing. The axis $x—x$ of the auger converges with the axis $y—y$ of the impeller 40. Furthermore by providing the clutch control handle 66 so that it extends over the top of the conveyor housing toward the right side thereof as viewed in FIGURE 2, an operator standing in the operating space generally designated 102 (FIG. 2) has ready access to the handle 79 as well as to the controls 103 of the wagon 91 and also to the tractor controls. Furthermore, the arrangement is such that the receiving deck 76 is disposed outwardly of the right wheel 104 of the tractor 30 whereby the conveyor 90 is adapted to be readily positioned in vertically overlapped relation to the intake 76 without the necessity of jocking the forage box behind the wheel 104. It will be realized that the wall portion 98, 99 (FIGS. 2 and 6) are spaced laterally with respect to the wall portion or lip portion 76 whereby the upper part of the auger trough rightwardly of the wall portion or deflector wall 99 is open to provide a large inlet 105 into the trough.

The novel and effective and ingenuous arrangement has been obtained as described in the foregoing disclosure which promotes the flow of the material through the auger conveying system or the trough conveyor and through the blower. Abrupt changes of direction of movement of the material are eliminated and the inertia of the material as it is entering into the blower housing is utilized whereby the capacity of the rotor is increased without the necessity of excessively driving the rotor. Stated in other words the rate of flow of certain quantities of material per unit of time are increased and therefore for smaller volumes the power requirements are reduced.

What is claimed is:

1. In a material conveyor, a blower comprising a housing having a generally cylindrical peripheral wall with an outlet opening and upright axially spaced side walls, an impeller journalled between said side walls on a generally horizontal axis and having paddles sweeping along the peripheral wall, one of said side walls having an inlet opening therein below said axis spaced circumferentially of the blower from said outlet opening, and generally horizontally arranged conveyor means disposed at approximately a 45° angle to the plane of the impeller and convarging with said plane in the direction of movement of the impeller and in direct feeding relation to the inlet opening, and said conveyor giving impetus to the material in the direction of movement of the impeller.

2. In a material conveying apparatus, a blower having a casing and an impeller rotatable therein on a generally horizontal axis, the casing having a generally tangential outlet and an axial inlet below said axis and generally horizontal conveyor means for delivering material directly to the blower through said axial inlet at an acute angle to the plane of the impeller in the direction toward the outlet, said conveyor means imparting an impetus to the material in the direction of movement of the impeller and augmenting the velocity of the material over that solely imparted by the impeller.

3. In a material conveying apparatus according to claim 2, a shroud overhanging said inlet and having a concave lower side and positioned in the stream of air incidentally exhausting from the inlet and providing a reentrant channel for said air into said inlet.

4. In a material conveying device, a blower having a substantially cylindrical housing with a generally tangential outlet opening and an axial inlet opening, an impeller rotatable within the housing on a generally horizontal axis and effective to carry the material from the inlet and discharge it through the outlet, said inlet located below said axis, a generally horizontally disposed conveyor extending diagonally to the axis of the housing from said inlet opening beyond the periphery of the housing and having a material receiver radially outwardly of the housing, said conveyor having a direct feeding trajectory diagonally disposed at an acute angle to the plane of rotation of the impeller and imparting an initial impetus to the material augmenting the movement of the material by the impeller.

5. In a material conveying apparatus a substantially cylindrical housing having a generally tangential outlet opening and an axial inlet opening displaced circumferentially with respect to the outlet opening, an impeller within the housing rotatable on a generally horizontal axis having a direction of rotation from the inlet opening to the outlet opening, a continuous generally straight generally horizontal conveyor comprising a conveyor trough connected to said housing and extending diagonally axially therefrom in a direction away from the outlet, an auger mounted in the trough and having its axis of rotation converging with the axis of rotation of the impeller in the direction toward the outlet opening, said inlet opening being located below said axis and said auger having direct delivery discharge into the inlet opening in a moving stream converging with the plane of the impeller toward said outlet.

6. The invention according to claim 5 and said inlet opening being offset approximately 90° from the outlet opening.

7. The invention according to claim 5 and said auger and impeller axes disposed substantially horizontally and said auger being rotated with its underportion advancing in the direction of movement of the adjacent portion of the impeller at said inlet opening.

8. In a material conveying apparatus, a generally cylindrical housing having a peripheral wall with a substantially tangential material outlet opening and having a pair of upright radial walls one of which has a material inlet opening, an impeller journalled between said radial walls on a generally horizontal axis, a generally horizontal trough extending lengthwise diagonally to said axis and having one end communicating with the inlet opening, said inlet opening being on the side of said axis remote from said outlet, said trough having an inlet area displaced transaxially of the housing and a single conveying means extending from said inlet area of the trough to said inlet opening in the housing, and said conveying means having a direct delivery of material into the inlet opening in a moving stream acutely converging with the axis of the impeller toward the discharge opening.

9. In a material conveying device, a generally cylindrical blower having a peripheral wall with a material outlet opening and a pair of upright side walls, one of the side walls having a material inlet opening in the lower portion thereof and a conveyor for delivering material to the blower comprising a U-shaped trough having one

end connected to said one side wall in alignment with said inlet opening therein, said trough extending lengthwise diagonally away from said one side wall beyond the peripheral wall, an auger mounted for rotation within the trough on a generally horizontal axis at an acute angle to said one side wall and extending to said inlet opening and directly delivering material into the inlet opening in a direction toward the outlet opening, and an impeller in the housing rotatable on a generally horizontal axis for engaging the material entered therein and augmenting said movement of the material, the axis of the auger converging with the impeller in the direction of rotation thereof.

10. The invention according to claim 9 and said auger having flights, and means for rotating the auger in a direction such that its lower edge moves in the direction of movement of the impeller at said inlet opening.

11. In a material conveying device, a generally cylindrical blower having a peripheral wall with a material outlet opening and a pair of upright side walls, one of the side walls having a material inlet opening and a conveyor for delivering material to the blower comprising a U-shaped trough having one end connected to said one side wall in alignment with said inlet opening therein, said trough extending lengthwise diagonally away from said one side wall beyond the peripheral wall, an auger mounted for rotation within the trough on a generally horizontal axis at an acute angle to said one side wall for delivering material into the inlet opening in a direction toward the outlet opening, and an impeller in the housing for engaging the material entered therein and augmenting said movement of the material the axis of the auger converging with the impeller in the direction of rotation thereof, and said auger having flights, and means for rotating the auger in a direction such that its lower edge means moves in the direction of movement of the impeller at said inlet opening, and a deflector extending over a portion of the trough adjacent to the housing immediately over the inlet opening therein and having a generally horizontal portion extending along the upper edge of said inlet opening and having a diagonal downwardly extending portion.

12. In a material conveyor, blower means comprising a housing having a pair of upright axially spaced walls and an intervening circumferential wall, an impeller having a generally horizontal shaft journalled through said side walls, said circumferential wall having an upwardly directed outlet opening, one of said side walls having a horizontally directed inlet opening disposed below the said shaft, an impeller mounted on the shaft and driven thereby, a material conveyor having a trough with an inner end connected to said one side wall, said trough being elongated in a direction diagonally away from said outlet and having an outer end displaced radially of the housing farther from the outlet than said inner end, said trough having sides diverging in horizontal planes away from the housing and having a top wall portion overhanging one side of the trough and providing with the opposite side of the trough an upwardly open material inlet opening, said top wall portion extending to said inlet opening in said one side wall and having a baffle means flapped over the inlet opening for directing air and material in a swirl pattern into said inlet opening.

13. In a material conveying apparatus, a blower comprising a housing having a generally tangential outlet and an axial inlet, impeller means in the housing aperture to direct air and material through the housing from the inlet to the outlet and for blowing incidental air through the inlet where material is being directed therewith by impingement against said material, auger conveying means extending diagonally toward said inlet, and shroud means encompassing the inlet and having guide portions extending axially of the blower and across the auger and providing a surface athwart the path of incidental air blasts and providing a reentrant surface directed toward the inlet opening on a side thereof opposite the area athwart the air blast for redirecting such air with entrained material into the inlet opening.

14. In a material conveyor, a housing having a pair of upright side walls, one of which has an axial inlet opening and a peripheral wall with an outlet opening, an impeller mounted within the housing and having a generally horizontal drive shaft journalled through said side walls, a material receiver connected to said one side wall and extending generally diagonally from the blower housing beyond one side thereof, said receiver having an auger trough bottom, said receiver having a material receiving area and an auger extending diagonally crosswise of said area to the inlet opening in the housing and having a delivery path for material diagonal to the impeller in converging relationship thereto in the direction of rotation of the impeller, means for driving the auger comprising shafting connected to the impeller shaft, and extending toward the end of the auger trough remote from the blower housing, shaft means mounting said auger from said last mentioned end of the trough and a driving train connecting said shaft means with said shafting.

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Feb. 7, 1967 T. J. SCARNATO ETAL 3,302,978

DIAGONAL FEED MATERIAL CONVEYOR AND BLOWER MECHANISM

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FIG. 2

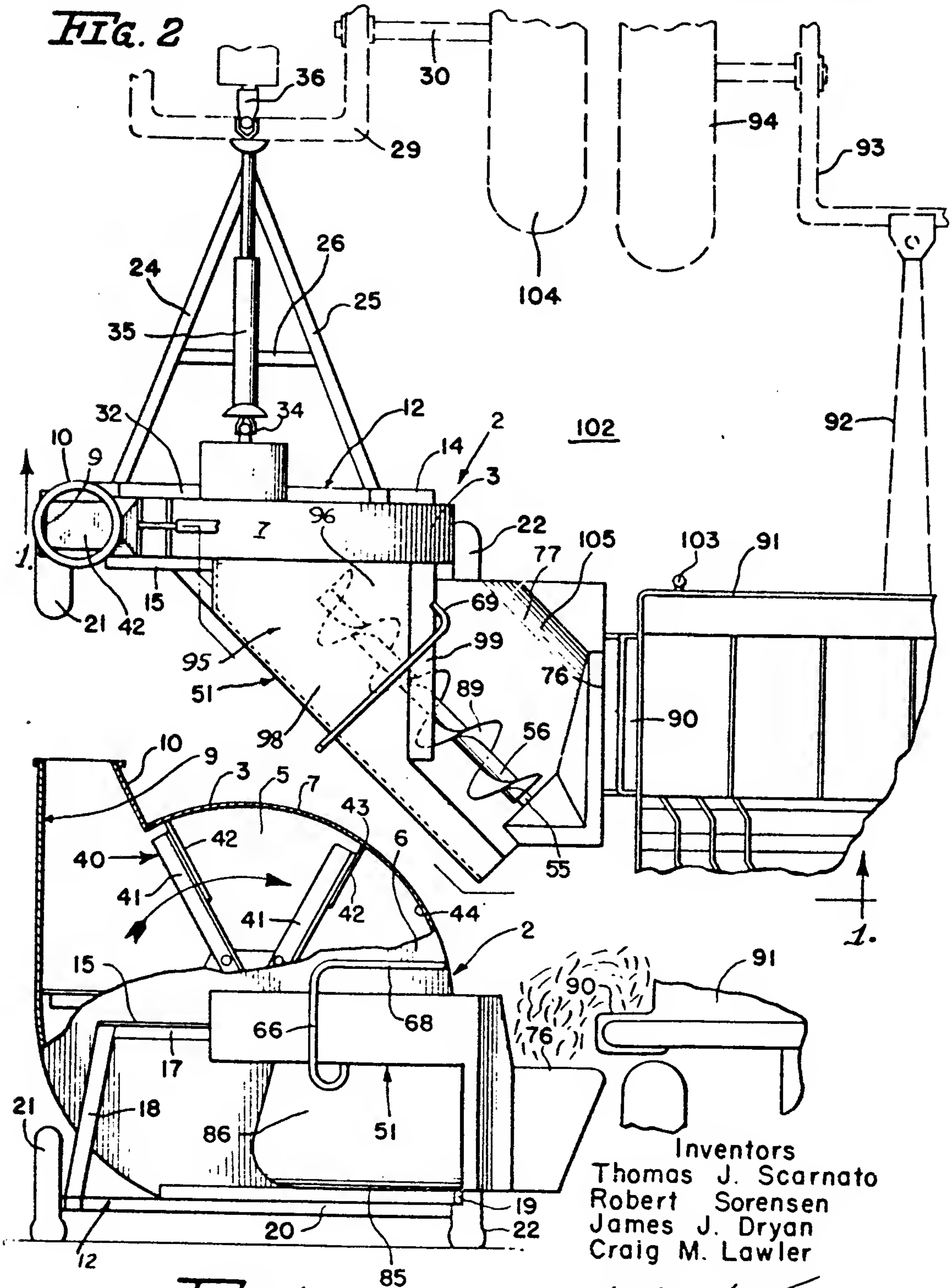

FIG. 1

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DIAGONAL FEED MATERIAL CONVEYOR AND BLOWER MECHANISM

Filed May 28, 1965 3 Sheets-Sheet 2

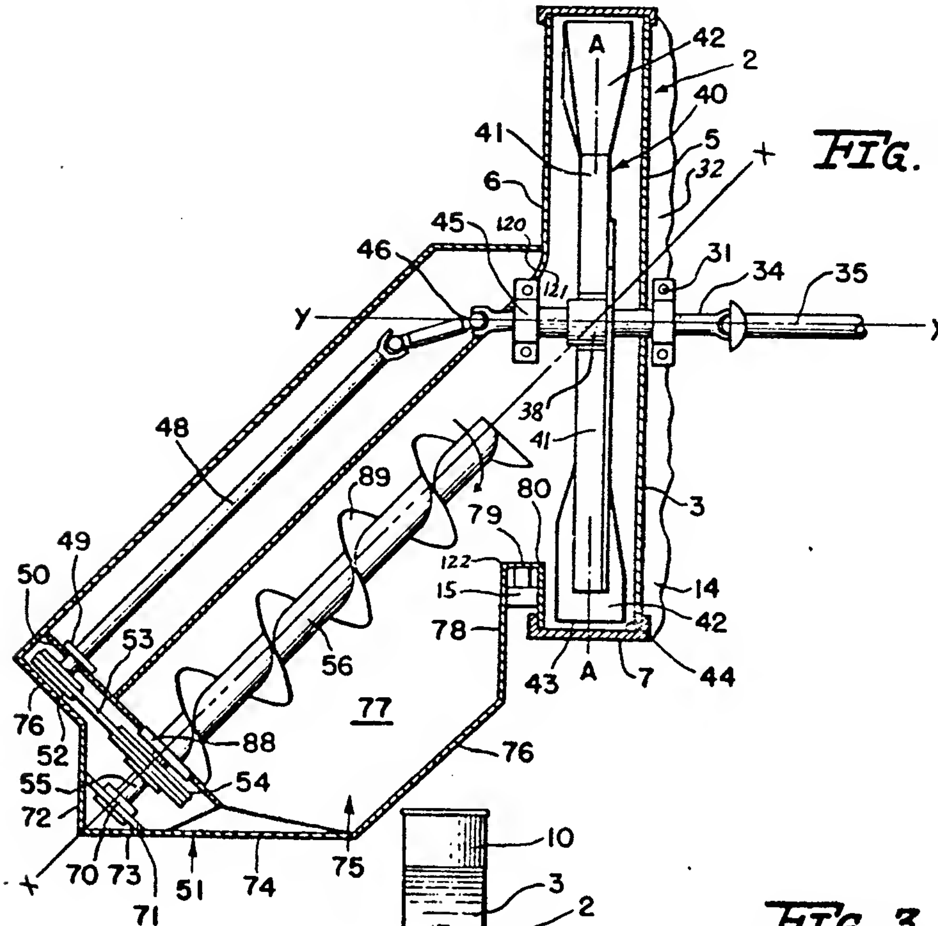

FIG. 4

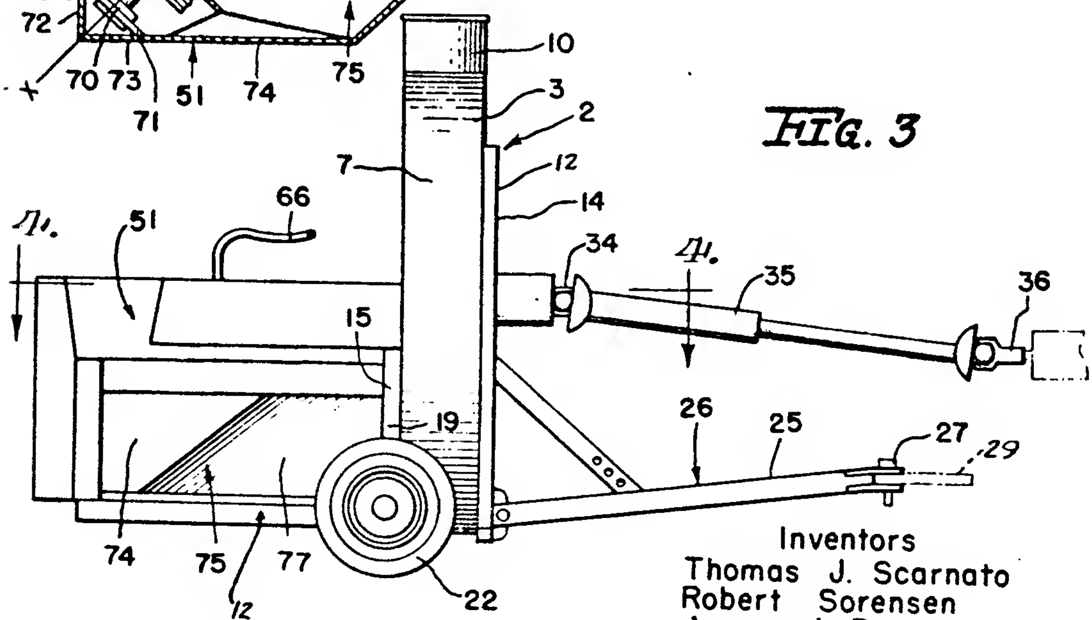

FIG. 3

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DIAGONAL FEED MATERIAL CONVEYOR AND BLOWER MECHANISM

Filed May 28, 1965

3 Sheets-Sheet 3

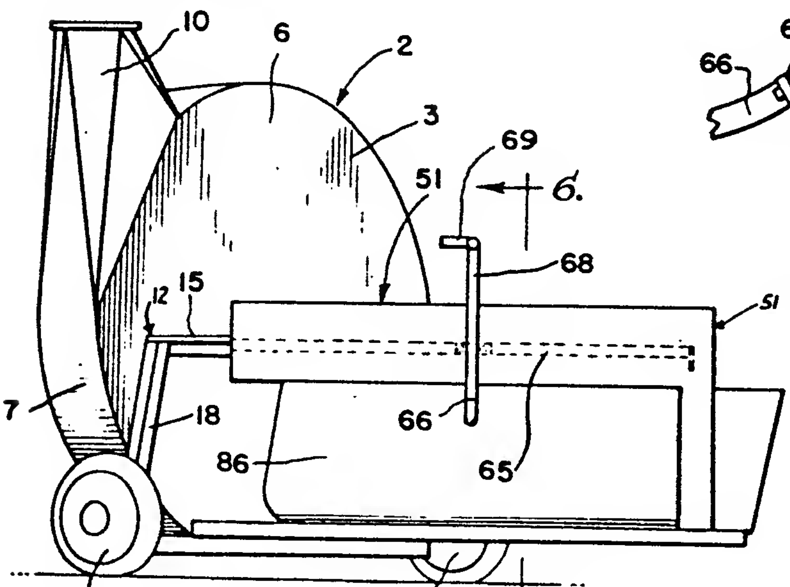

FIG. 5

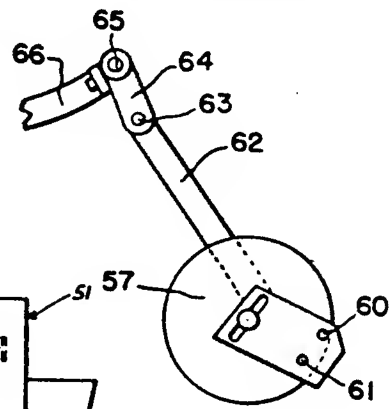

FIG. 8

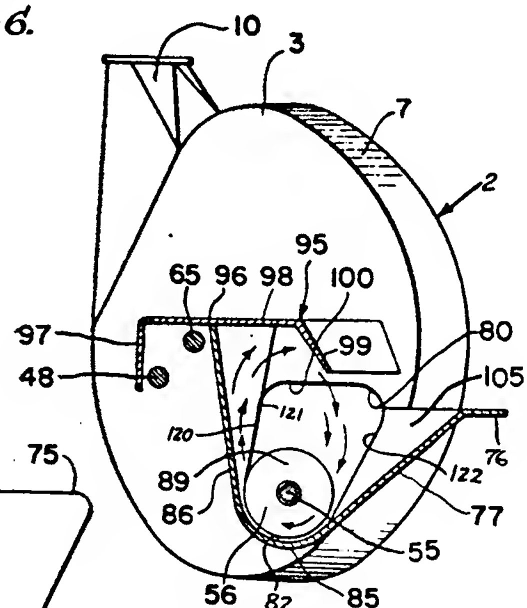

FIG. 6

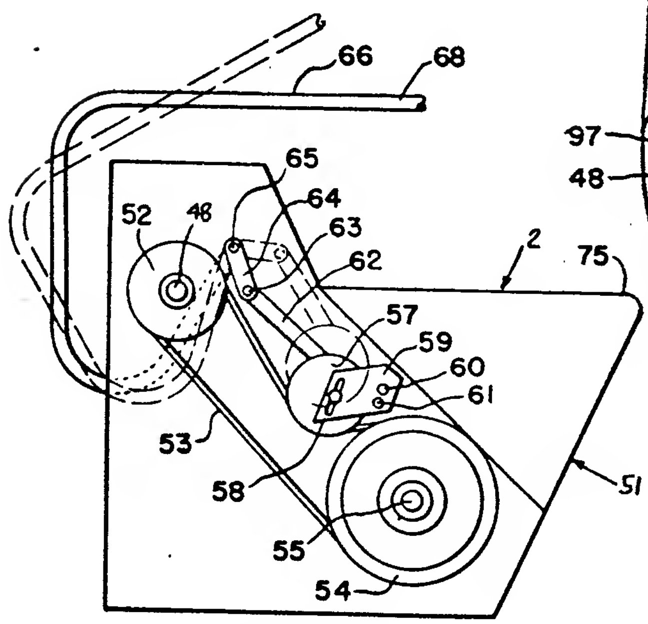

FIG. 7

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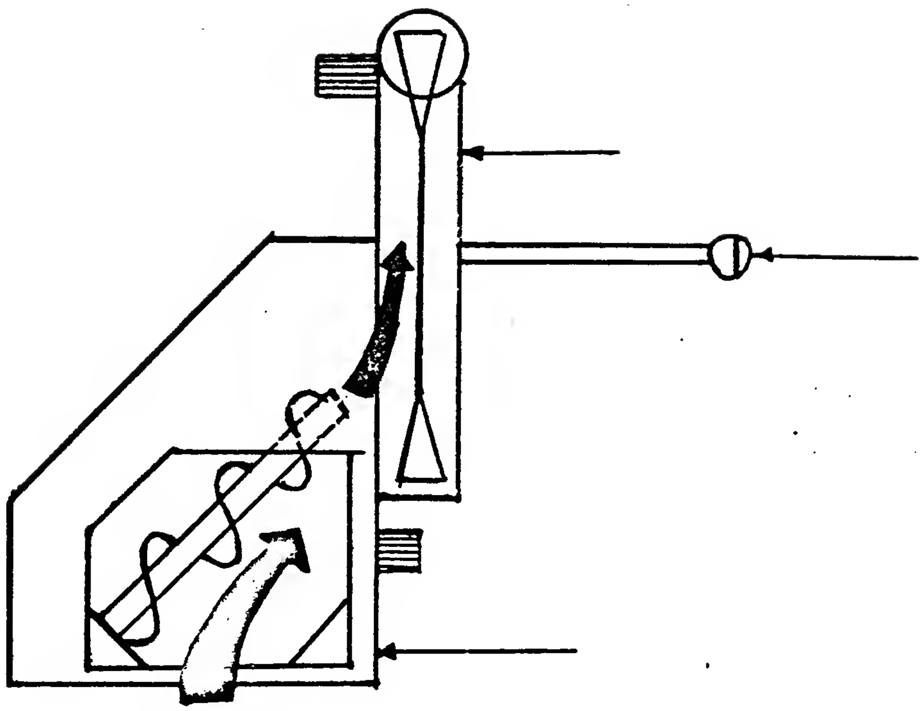
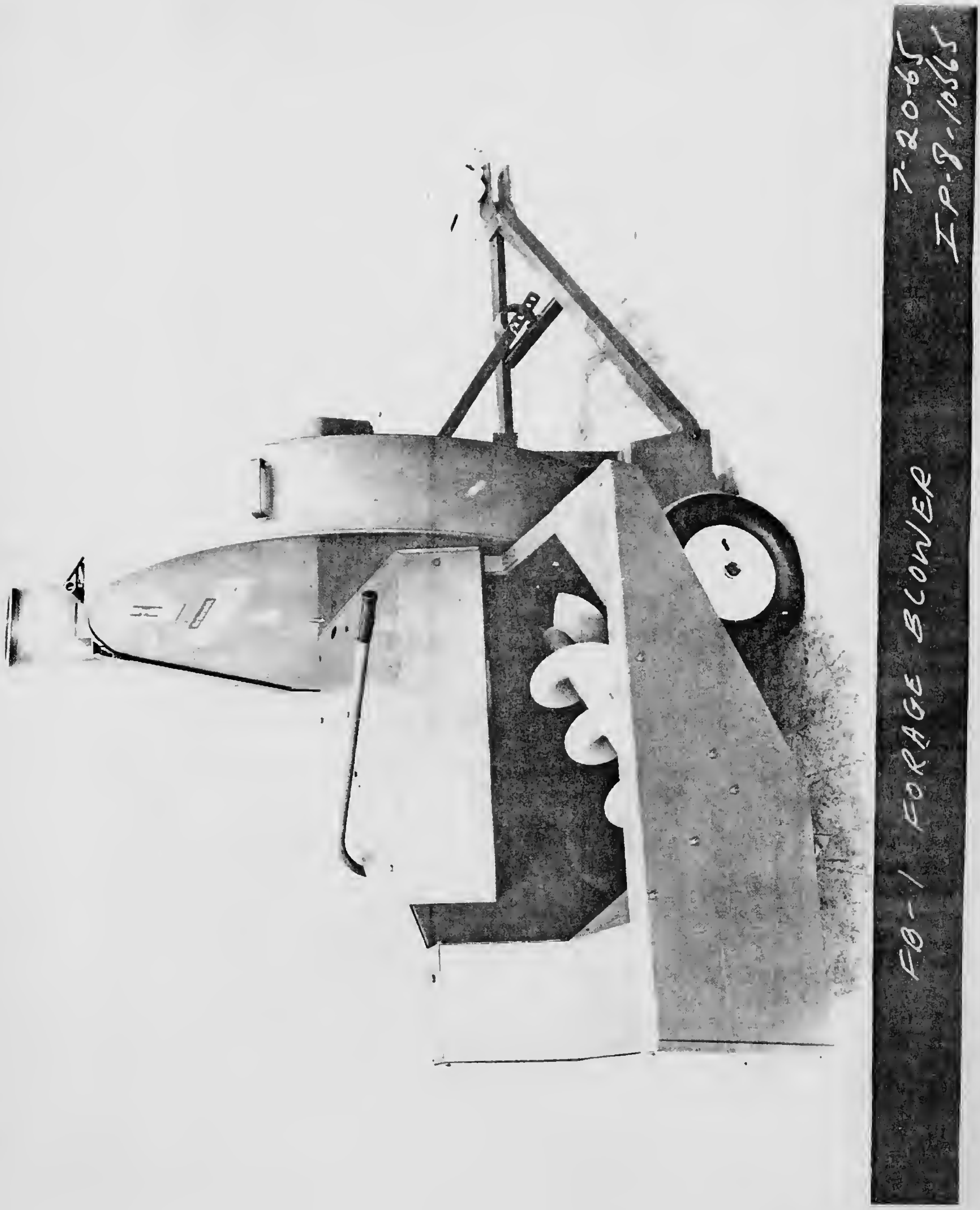
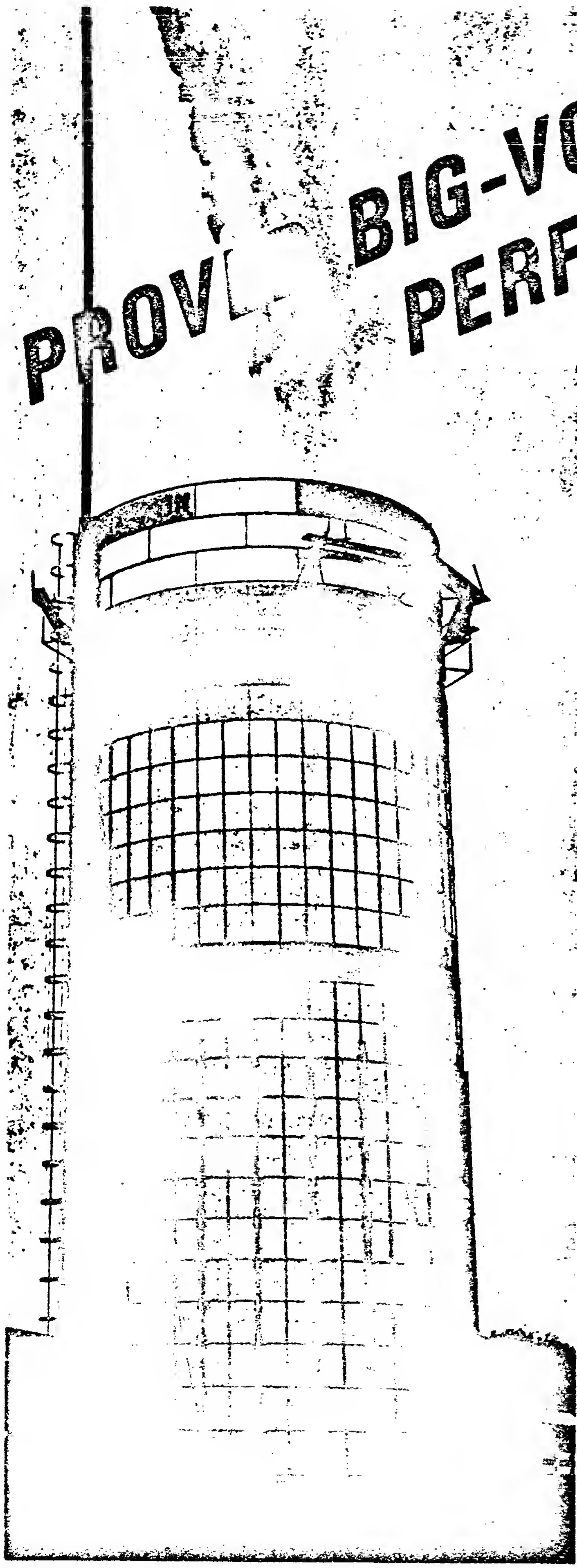
Diagonal Feed Path

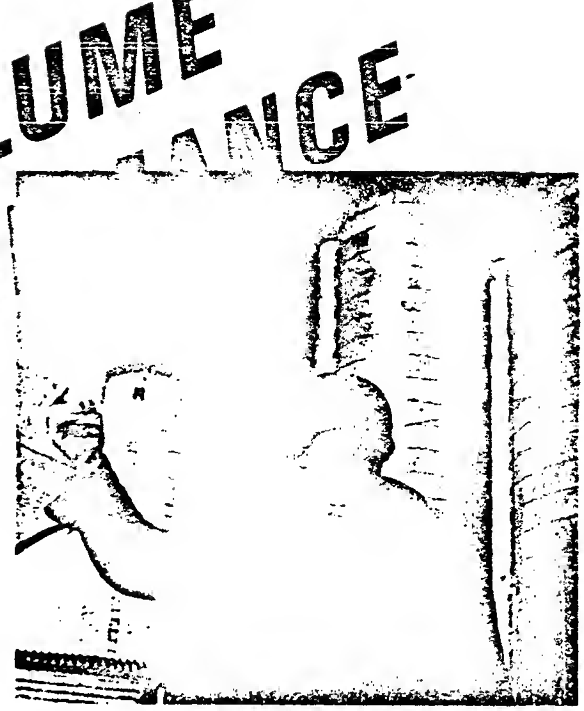


Specifications

Capacity	70 tons per hour (haylage) 100 tons per hour (corn silage)
Blowing height	Elevates haylage over 100 feet
Horsepower required	30 HP or more depending on silo height, crop and rate of feeding
Blower housing dia.	56-inch
Blower housing outlet dia.	9-inch (inside)
Height to outlet	62.5 inches to 68.6 inches
Number of paddles	6
Rotor speed (operating)	540 r.p.m.
Hopper auger	10-inch dia., 39 inches long
Hopper dimensions	34 inches wide, 23 inches deep (inside)
Hopper height from ground	21.4 inches to 27.4 inches
Drive Line	Power take-off - direct drive 540 r.p.m.
Tire size	4:00/4.80x8
Wheels	3 transport heights. Also swing up to rest frame on ground.
Weight	950 lbs.


FO-1 FORAGE BLOWER
7-20-65
IP-8-10565





Cheshire, Ohio
November 18, 1965

International Harvester Company
Chicago, Illinois

Gentlemen:

I wish to congratulate your company in regard to the new No. 56 Blower, which I have had the privilege of using this fall in filling my 30 x 80′ silos.

The No. 56 has 50% more capacity than any blower that I have ever used. It can unload a five-ton wagon of silage with ease in 2½ minutes. Also, I want to congratulate you on the low power required to throw haylage or corn silage into my 80-foot jumbo silos.

I feel that you can recommend the No. 56 Blower to work with a three-plow tractor to a customer who *really* wants capacity and performance. It has the lowest feed hopper that I have ever used. With the adjustable door and the slant auger system that you have designed in this machine, I have seen nothing built that will equal the even feed with no slugs. This is the most perfect machine that I have used in my lifetime. Also, it is the easiest machine to set up to the silo; because of its design, it can be handled and steered with your tractor in tight spots.

Sincerely yours,
(Signed) Ura Swisher

P.S. I have been most enthused with this machine, so I thought I would do an experiment after I finished my last 30 x 80 silo. I borrowed extra blow pipe from my brother and tried to blow corn silage to the "ole cow who jumped over the moon," but I did not quite get to the moon, as I got part way, 130 feet, for that *was all the pipe* that I had.

Instructor's Notes for Forage Blower Development at International Harvester

Ibanga Ekong
Rollin C. Dix

This case describes the problems discovered in testing a new concept for a forage blower design and the eventual successful completion of the project despite abandonment of the original concept.

In Part A the need for the project, the company situation and the new concept are described. In discussion of question (a), the students might be asked to allocate funds to analytical and experimental programs. Question (b) forces the students to consider friction and air flow within the blower, but their answers tend to be rather qualitative. For example, few will notice that there is no air inlet. Chopping of the haylage at the blower periphery is another problem overlooked. The instructor must avoid leading too much in this discussion. In attempting to answer question (c) the students will recognize the necessity for experimentation. Discussion of what to measure and how to use it in redesign is interesting.

Part B describes some analytical and experimental work which has been performed to aid forage blower designers. The student will quickly learn that merely reading through such articles does not provide the information needed for a particular design. The most important information here is that provided by Figure 7 in Exhibit 1 which shows the importance of air flow in blower operation.

Question (1) is answered by integration of the equation derived from a simple force balance on particles in the delivery tube. Question (2) is answered by an analysis similar to that provided for item 4 on page B1 and B2 except that V_r is replaced by the particle velocity component perpendicular to the wall. Item 3 can also be discussed in class. Its derivation follows from consideration of "potential" energy change of particles in the centrifugal force field.

Part C reports the results of experiments which in retrospect should never have been performed. However, the information gained from these "unsuccessful" tests led to the success described in Part D. The explanation of the test results lies in the radial flow of air and the accompanying total pressure increase in a centrifugal blower. When there are no air holes in the blower housing, entry air is supplied in the clearances at the two sides of the impeller.

In Part D International Harvester's "diagonal feed conveyor" concept is described. The reverse air blast was eliminated by moving the feed inlet back up toward the impeller center and providing a closed periphery.